THE ANATOMY AND PHYSIOLOGY OF THE HUMAN BODY.

BY

JOHN AND CHARLES BELL.

THE WHOLE MORE PERFECTLY SYSTEMATIZED AND CORRECTED

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WITH VARIOUS IMPORTANT ADDITIONS, FROM THE WRITINGS
OF SOEMMERING, BICHAT, BECLARD, MECKEL,
SPURZHEIM, WISTAR, &c.

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OF THE VEINS.

The veins are the vessels by which the blood carried outward by the arteries is returned to the heart. The system of the veins, however, is not so simple as that of the arteries, for while there are only two great arteries carrying the blood from the heart, viz. the aorta and the pulmonic artery, there are three great trunks of the veins, viz. the superior and inferior vena cava, which are the trunks of the great veins of the body; the pulmonic vein, which returns the blood to the heart from the circulation through the lungs; and the vena portæ, which collects the blood of the intestines, and conveys it to the liver. There is, besides, a greater variety in the distribution of the veins than in that of the arteries.

The French physiologists have departed from the old method of Harvey, in explaining the circulation. He wisely took the heart as the centre of the system, and described the vessels going out from it, forming the two circulations, viz. through the body and through the lungs; but they have assumed the lungs as the centre; and the veins of the body, and the arteries of the lungs, they call *systeme a sang noir*, because it contains the dark-coloured blood; and the pulmonic veins and the arterial system of the body they call *systeme a sang rouge*, because it conveys blood of the bright vermilion colour.

This conceit is perhaps admissible, when introduced as an additional illustration of the relation of the lungs to the body; but it causes in a difficult subject an unusual degree of intricacy, and does not serve the purpose of demonstration: besides, the arteries and veins of the body, and the pulmonic artery and vein, have that strict and mutual dependance in action, which shows how improper and how unnatural it is to make this change, and to separate them in explaining the general system. At all events, let those who adopt this novelty cease to speak of the two circulations, for although in regard to the heart there are two circulations, yet as the movement of the blood respects the lungs there is only one. By this division, the blood returning from the body, and carried into the lungs, cannot be called a circulation; but only when it has passed through the lungs, and returned to the same point of its course through the body.

I retain the old method, corresponding with what has been delivered in the preceding volume, and in describing the veins will follow the course of the blood through them.

GENERAL CHARACTER OF THE VEINS.

The capacity of the veins is greater than that of the arteries; the coats are thinner but stronger comparatively, and admit easily of dilatation to a certain extent. The coats of the lesser veins are comparatively stronger than those of the larger ones, and the veins of the lower extremity much thicker and stronger than in the upper parts of the body, as they have to bear a higher column of blood. The veins are transparent

and the blood is seen through their coats. The veins have three coats. The *outer* coat is composed of a reticulated tissue of cellular membrane, which is wrapped somewhat loosely around the proper coats. The *second* coat has the same character of an interwoven texture of filaments; but is more dense, especially on its internal surface, where it approaches the inner coat. The inner coat is dense and unelastic, resembling the inner coat of the artery, but stronger, more pliant, and less easily ruptured by a ligature than the inner coat of the artery. Betwixt all the coats there is a fine cellular substance interposed.* The inner coat being smooth and flexible is formed into valves in various parts of the veins; which valves are semilunar, and resemble those in the root of the great arteries in the heart.

In all the larger veins, excepting those of the viscera, of the abdomen, and those of the lungs and brain, there are valves; but in the smaller veins there are no valves. These valves, as I have said, consist of the inner coat, forming folds like a curtain, hung across the calibre of the vein, but at the same time attached so obliquely to the side of the vein, that they present a sacculated membrane, the edge of which is caught by the blood the instant that the stream is retrograde, and thus the valve is raised, and falling back, stops the return of the blood against its natural course. The loose margin of the valve is somewhat stronger than the other part, and betwixt the duplicature of the inner membrane forming it some little filaments may be observed. Each valve consists, in general, of two semi-lunar membranes, the margins of which fall together; but they yield and give freedom to the current of blood when flowing towards the heart.

Authors have not noticed a part of the structure essential to the operation of a semi-lunar valve. I mean the little sinuses or more dilatable part of the coats of the veins just above the attachment of the valve. The sinuses are of the same use here that they are at the origin of the great arteries from the heart. By their means the margin of the valve is not permitted to touch the side of the vein. The blood always intervenes betwixt the valve and the side of the vein, consequently the slightest retrograde motion of the blood throws down the valve. Without this provision, the valve being collapsed to the side of the vein, the blood would have been permitted to pass retrograde.

A ligature high on the arm or thigh not only causes the veins to swell by preventing the free course of the blood back to the heart, but it shows the veins in their distinct and natural character, and causes the sinuses of the valves to rise, showing the places of the valves.

The sacs formed by the valves of the veins are much deeper sometimes than the term semi-lunar implies, insomuch that the term pyriformis has been used. Neither are the valves always double, for sometimes they are single, and sometimes three in number.† They are best seen by opening the veins under water, and drawing them to and fro, by which it will be perceived how the valves rise and float.

As the veins are provided with valves only where they are exposed to

* Unless near the auricle no muscular fibres have been observed. See Halleri Opera Minora, p. 175.

† Fabricius de Venarum Osteolis. Morgagni Epist. Anatom. XV. Kerckringii Spicilegium Anatomicum, Tab. 4.

occasional pressure, and particularly to the compression of the muscles, the use of the valves would seem to be, to prevent the retrograde movement of the blood, in consequence of the occasional and partial compression of the veins; but, no doubt, they at the same time support the column of blood, as in the lower extremities: and when those veins suffer distention by disease, a great aggravation of this condition is, that the valves lose their action, for the vein is now too large to be closed by them, and the whole column of blood presses upon the veins of the legs.

Fabricius ab Aquapendente, who discovered the valves of the veins, though ignorant of the circulation, and, consequently, of the true use of the valves, yet argues very ingeniously; for he imagined that exercise, by heating the limbs, would draw the blood from the trunk, to the injury and rupture of the vessels of the limbs, and the too great diminution of nourishment in the vital parts, were it not for the office of these valves. See, says he, how the veins swell, and the valves become marked and distinct, when a man is in full exercise. By this we may perceive, that exercise forces the blood out from the body towards the extremities, and would do it too powerfully, but for the operation of the valves. But Harvey, observing the mechanism of these membranes, was drawn to conclude that the blood must always run in one direction in the veins, and, consequently, that there must be a circulation of the blood.

The commencement of the minute branches of the veins is from the extreme ramifications of the arteries; they are continuous, and convey back the blood in that course which is called the circulation. In contemplating the capillary tissue of vessels, the most striking circumstance is, the predominance of the dark venous ramifications: and in general, two sets of veins will, even in these minute ramifications, be observed; one superficial, the other more intimately blended with the minute ramifications of the arteries; but in the internal parts of the body, and particularly the viscera, the veins uniformly accompany the ramifications of the arteries, and in the solid viscera a dense cellular membrane gives lodgment to both sets of vessels.

It was supposed, even after the time of Harvey, that there was a spongy or cellular substance betwixt the extremities of the arteries and veins; but there is no such thing in the microscope. I see the globules of the blood following each other in rapid succession, and turn, and accumulate, and retrace their course. There can be no doubt, that when they are passing rapidly, as one may say, in single files, they are in the extreme arteries. That again, when they turn back, and go two and two or three abreast, they are in the extremities of the veins. I may further observe, that in the microscopical experiments we do not see the coats of these small vessels, but must conclude that they are there, from the globules of the blood being accurately confined to a certain tract or course.

In the extremities and head, indeed every where but in the viscera, the veins form two distinct sets; the deep and the superficial veins: 1. the deep veins accompanying the arteries; and 2. the sub-cutaneous veins, which emerge from the compression of the muscles, and run above the fascia. The union betwixt the branches of the veins is very frequent, not only betwixt the veins, ramifying in the same plane inso-

much as to make them a net-work, but also betwixt the deep and the superficial set of veins: such are the venæ emissariæ of the skull, the free communications betwixt the external and internal jugular vein, betwixt the deep and superficial veins of the arm, &c. When in bleeding, the blood flows from the vein of the arm, accelerated by the working of the muscles, the blood escapes by the anastomosis, from the compression of the muscles, and fills the superficial veins; but the increase of the jet of blood is principally produced by the swelling of the muscles, causing the fascia to compress the internal veins of the fore arm.

In the dead body the veins are flat, but when distended they resume the cylindrical figure which they possessed in the living body; yet they are in general of the cylindrical figure for a very small part of their course only, owing to the irregular dilatations by the side of the valves, and to the frequent union of their branches. The manner in which the branches join the trunk has a peculiarity which always distinguishes them from the ramifications of arteries: the arteries branch direct and at an acute angle, the veins in a direction more removed from the course of the trunk, and in general with a curve or shoulder.

In infancy and youth the veins are but little turgid, and especially the cutaneous veins are so firmly embraced by the elastic skin and cellular membrane, that they have a less degree of prominency than in more advanced years. In old age the veins are enlarged, and rise turgid on the surface; the internal veins also become enlarged, and the whole venous system is extended.

Sœmmerring says, with increasing years the resisting power of the veins is diminishing, that of the arteries increasing. I believe this to be incorrect in regard to both kinds of vessels.

I do not consider the change in the vascular system as the effect of mere distention, or of the enlargement of the veins, from the long continued action of the arteries; but as a necessary change in the proportionate distribution of the blood, which is preceded or accompanied with other peculiarities, which characterize old age. When we consider the great size of the veins, compared with the arteries, we must conclude that the blood flows but slowly in the venous system; that from the narrowness of the trunks of the veins near the heart, the blood must be accelerated as it approaches the heart; and that receiving the impulse from the ventricle, it must take a rapid course through the arteries, until, again approaching the extreme branches of the arteries, and passing into the veins, its motion becomes more languid and slow. In youth, as the size of the veins is not in so great a proportion to the arteries as in advanced life, the blood in a young person must be in more rapid and quick circulation: but in old age, owing to the largeness of the veins and the accumulation of blood in them, the blood moves slowly through the venous system, and is almost stagnant in the dilated veins and sinuses; upon the whole, it moves less briskly through the vessels, and the proportionate quantity immediately under the influence of the arterial system is less than in youth.

There is no pulsation to be observed in the veins, but what they receive laterally from the contiguous arteries. There is no pulsation in the veins, because they are removed from the heart; because they do not receive the shock of the heart's action in their trunk, but only by

their widely-spread branches; because the contraction of the heart and of the arteries so alternate with each other, as to keep up a perpetual and uniform stream of blood into the veins; whereas the pulsation in the arteries is owing to the sudden and successive contractions of the heart.

In living animals I have undoubtedly seen the course of the blood in the great veins near the heart alternately checked and accelerated in its motion. But this is a subject which I have no disposition at present to pursue. This motion does not prove that there is here a muscular contraction.*

FUNCTIONS OR USES OF THE VEINS.

Are the veins merely for carrying back the blood to the heart, and are they entirely passive, while the arteries alone are agents? Although it appears that the veins have no muscular action in their coats, yet such is the peculiarity of their situation, that they become, in an indirect manner, powerful agents in circulating the blood. In the first place, we see that by their great number, their width, and large diameter, they contain a large proportion of the blood; in the second place, they are under the influence of the muscular system, so that every motion or effort compresses them, and causes a movement of the blood within them. If a long tube be attached to a vein of a living animal, so that the blood may rise into the tube, in height proportioned to the force of circulation, and if the animal be excited to exertion, in the moment of exertion the blood is forced in a jet from the mouth of the tube. This explains what the influence of exercise must be in accelerating the circulation. And now we see the proper use of the valves; for these sudden efforts of the muscular frame, compressing the veins, would cause a movement of the blood backward; the impulse would be at least as powerfully retrograde upon the course of the blood as forward. But as these flood-gates are thrown down on the slightest movements of the blood, contrary to the course of the circulation, and the retrograde motion of the blood thereby prevented, the muscular force is all given in aid of the circulation, and the blood of the veins is thereby forced on to the right side of the heart.

In this general account of the venous system, it remains only to speak of the subject of absorption by veins. Before the suite of experiments made on this subject by Mr. Hunter, a vague notion was entertained that the veins were absorbents; but about that time†, the doctrine that lymphatics were absorbents having been established, the opinion that

* In exercitüs immodicis, &c.—fortius ad cavam et cor dextrum accedit quam in quiete, ergo, cor dextrum magis dilatatur, et ad majorem contractionem coactum, fortius impellit sanguinem in pulmonem: verum ille impetus adauctus, concurrens cum inspiratione, infarctum addit infarctui: ergo et magis pulmones aggravat.—*Sauvage's Nosol.* tom. iii. p. 136.

Post. D. Schligking observavi venas omnes, saltem majores, detumescere et complanari durante inspiratione: intumescere vero et retundi durante exspiratione.—*Ibid.*

Haller found contraction produced in the veins by touching them with oil of vitriol. *Opera Minora*, p. 375.

† 1758.

the red veins were also absorbents was first questioned, and finally confuted, at least in the opinion of most physiologists.

The chief argument to show that veins, arising from cavities, particularly from the intestines, acted as absorbents, was, that some anatomists said they had seen white chyle in the blood taken from the mesenteric veins. It was however, soon observed, that the serum of the blood taken from the veins of the arm, was sometimes white, which must arise from some other cause than the absorption of chyle.*

The experiments of Mr. John Hunter proved that there is no absorption of fluid from aliment contained in the intestinal canal, by the veins of the mesentery, while the lacteals were rapidly absorbing. Emptying a portion of the gut, and the veins of their blood in a living animal, he poured milk into the intestine. The veins remained empty and without a drop of the milk finding its way into them, while the lacteals became turgid with it. In another experiment, leaving the arteries and veins of the mesentery free, and the circulation through them perfect, still no white fluid could be discovered, tinging the stream of blood in the veins. Neither did pressure upon the gut in any instance force the fluid of the intestines into the veins. He repeated and varied these experiments, so as to show, in a very satisfactory manner, that chyle, or the fluid of the intestines, never is absorbed by the veins.

Yet I must say that these experiments are still unsatisfactory, as they regard the general doctrine of absorption by the veins: in the intestines there is a peculiar set of vessels evidently destined to the absorption of the chyle and of the fluids of the cavity; but there remains a question which will not be easily determined: do not the veins throughout the body resume a part of that substance, or of those qualities, which are deposited or bestowed by the blood of the arteries? Are we assured that in the circulation of the blood through the lungs, and in the extremities of the pulmonic veins, there is no imbibing or absorption? In the veins of the placenta there is not only an operation similar to what takes place in the extreme branches of the pulmonic circulation, but the matter and substance which goes to the nourishment of the fœtus must be imbibed from the maternal circulation.† So by the vessels in the membrane of the chick in ovo there is absorbed that which, being carried to the chick, bestows nourishment and increase. If it be observed that in those operations of oxygenation matter is not absorbed, but only carbon thrown off, it only shifts the argument, without weakening it; for if the carbon be thrown off in the lungs, this carbon is absorbed by the veins in the circulation of the body, which amounts to the same thing to our present argument. For my own part, I cannot but suppose that, while the lymphatics absorb the loose fluids which have been thrown out on surfaces or into cavities, the veins receive part of what is deposited from the arteries, but which is not so perfectly separated from the influence of the circulating system as that which the lymphatics receive; and that there are certain fluids, which, by an affinity of the venous blood, they imbibe in the course of the circulation. We must at

* See Hewson, Exper. Essays and Lymphatic System.

† Dr. Hunter, Hewson, &c. say that it is probable there are many small lymphatics in the placenta, which open into the branches of the veins, and do not take a course along the cord.

the same time acknowledge, that the conclusions made in favour of absorption by veins, from experiments upon the dead body, are fallacious, and have no weight. It is seldom we can determine whether minute injections have taken a course by a natural or by a forced passage; neither are the experiments of some of the older physiologists more satisfactory or conclusive. Lower affirmed that, by throwing a ligature on the inferior cava of a dog, he produced ascites. He tied the jugular veins of a dog, and the head became dropsical. Hewson repeated these experiments, but without the same result. And if the tying of the veins had always produced œdema or dropsy, the experiment would have proved nothing more than is already established by the very common occurrence of œdema of the legs from the pressure of the womb on the iliac veins, or a tumour in the groin or in the pelvis. Now in these instances the compression of the vein does nothing more than cause a difficult circulation of the blood from the extreme arteries into the veins, and consequently a greater profusion of the discharge into the cellular texture by the serous arteries. But even the experiments of Mr. Hunter on the veins of the intestines are not in unison with the experiments of Sir Everard Home, who finds that the matter in the stomach and intestines is received into the system, although the thoracic duct has been tied or cut.

On the whole, we must either admit absorption by veins, or that there are many communications betwixt the lymphatic vessels and red veins in the extremities of these vessels.

OF THE VEINS, BRANCHES OF THE SUPERIOR VENA CAVA.

The superior vena cava, or the descending cava, is the superior trunk of the venous system; which receives the veins of the head, neck, and arms, and throws the blood directly into the great right sinus or auricle of the heart.

But I hold it better to begin my description from the extremities of the veins, following the course of the blood. I therefore commence with the veins of the forehead.

OF THE VEINS OF THE HEAD AND NECK.

The ANTERIOR FACIAL VEIN.* The facial or anterior facial vein runs down obliquely from the inner canthus of the eye, towards the angle of the lower jaw-bone. Here, uniting with the temporal vein, it forms the external jugular vein. The most remarkable branches of veins which assist in forming the facial vein are the FRONTAL VEINS; which receive the blood from the forehead and frontal portion of the occipito-frontalis muscle, and the OPHTHALMIC VEIN, which is one of the emissariæ, and comes from the cavernous sinus through the orbit. In its course down the cheek, the facial vein receives the several cutaneous branches of the veins from the surrounding parts: but which have in reality no such importance as to require description.†

* *Facial vein; V. Angularis; V. Triangularis.*

† *Vena dorsalis nasi, superior et inferior—Vena palpebralis inferior externa et interna—Vena alaris nasi—Venæ labiales magnæ et minores, &c.—Venæ buccales, &c.*

The POSTERIOR FACIAL VEIN*, or GREAT TEMPORAL VEIN.—This vein descends from the temple before the ear, and passes through or under the mass of the parotid gland, and behind the angle of the lower jaw.

This posterior vein receives those branches which are the proper temporal veins, and which are four in number, and descend upon the side of the head† ; and those which answer to the submaxillary artery, and also the vena transversa faciei, and the auricular veins. Finally, into some of the deep branches of this vein‡ the blood enters from the veins accompanying the arteria meningea. The posterior facial vein, uniting with the anterior one, forms a common trunk, which in general lies over the division of the carotid artery.

EXTERNAL JUGULAR VEINS.

The external jugular vein lies under the fibres of the platysma myoides muscle, takes a course obliquely down the neck, and across the middle of the mastoid muscle, and drops either into the subclavian vein or into the internal jugular vein. Sometimes there are two external jugular veins on each side ; more commonly there are two branches high in the neck, from the anterior and posterior facial veins, which unite about the middle of it. When they are double they have this course ; the *anterior and external* jugular vein may be said to begin from the anterior facial vein ; it then receives the submental vein which comes in under the base of the lower jaw—the ranine veins also, and veins from the glands under the jaw, join it here : where it is before the mastoid muscle, it forms free communications with the internal jugular veins ; and here also it receives veins from the side of the throat.§

Almost all the ramifications of veins, which in one subject unite in the external jugular vein, and which come from the face and throat, do in others sink down into the internal jugular vein.||

Sometimes the anterior and external jugular veins join the internal jugular vein ; sometimes the subclavian vein.

The POSTERIOR EXTERNAL JUGULAR VEIN is formed chiefly by the temporal vein, or posterior facial vein, which comes down from under the parotid gland ; it is then joined by the occipital veins¶, a little lower by the cervical veins, and lastly, on the lower part of the neck, it receives the muscular branches from the flesh of the shoulder ; it then sinks into the subclavian vein.

Of THE THYROID VEINS.—The thyroid gland has two sets of veins as it has of arteries ; the *superior thyroid* veins carry back the blood from the muscles of the fore part of the throat, from the larynx, from the substance of the thyroid gland, and from the neighbouring part of the trachea and pharynx, and even from the fauces. Sometimes these thyroid

* *Joannis Gottlieb Walteri, tab.* ii. 65.—*Venarum Capitis et Colli.*

† Being in two sets, the deep and superficial. Walter, tab. ii.—*Vena tempor. superf.* 110. *et Vena temp. profund.* 111.

‡ Viz. *Venæ Pterygoideæ.*

§ Viz. the superior thyroid veins, and the deep laryngeal veins.

|| Walter, loc. cit. tab. ii. 13.

¶ These communicate with the vertebral veins, and, through the posterior mastoid foramen, with the lateral sinus.

veins enter the external jugular vein; sometimes they descend upon the neck, taking the name of GUTTURAL VEINS, and unite themselves with the internal jugular vein.

The LOWER THYROID VEINS come from the lower part of the thyroid gland, and descend upon the fore part of the trachea, and enter the subclavian, or more generally, the great or internal jugular veins.

OF THE INTERNAL JUGULAR VEIN.—JUGULARIS INTERNA.*—VENA JUGULARIS CEREBRALIS.†—The internal jugular vein is formed by the conflux of the several great and posterior sinuses of the dura mater into the lateral sinus, which, coming out by the foramen lacerum posterius of the basis cranii, ceases to be constricted into the triangular shape, and takes the form and peculiarities of a vein. From this foramen, common to the temporal and occipital bone, the jugular vein descends obliquely forward and downward, becoming from its deep situation somewhat more superficial, but in all its extent protected by the sterno-cleido-mastoideus muscle, and passes under the omo-hyoideus muscle. The internal jugular vein is very irregular in its form; being sometimes much contracted under the angle of the jaw; bulging and much enlarged, or rather capable of being much distended in the middle of the neck; and again contracted before it joins the subclavian vein. The carotid artery, the internal jugular vein, and the par vagum lie together in the same sheath of loose cellular membrane. The vein is to the outside of the artery, and the nerve is betwixt them, lying a little deeper.

The internal jugular vein receives these communications and branches: behind the angle of the lower jaw, a branch of communication generally goes down from the posterior facial vein, and often it is joined by the internal maxillary vein; under the jaw, it either forms free communications with the beginning of the external jugular vein, or it receives the ranine and guttural veins: at all events, there is a branch from the side of the throat and the muscles of the os hyoides, which passes into the internal jugular vein. From under the back part of the mastoideus muscle, the internal jugular receives branches from the occipital veins, and at the same time has communications with the vertebral veins. Near its termination the great jugular vein receives the guttural and lower thyroid veins.

OF THE VERTEBRAL VEINS.—There is difficulty in assigning origins to these veins, for they are rather like a chain of communication; they run in the holes of the transverse processes of the cervical vertebræ, and surround the processes with areolæ. First, a communication is formed with the great lateral sinus, then they receive the flat sinuses from under the dura mater, covering the cuneiform process of the occipital bone, (the basilar sinuses,) and as they descend they form transverse communications, which receive the branches of that chain of inosculations, which runs down upon the spinal marrow. The vertebral veins, in their descent, send out divisions which run down upon the outside of the canal, and receive branches of veins from the muscles on the fore part of the vertebræ, and some of the proper cervical veins from behind. The *vena cervicalis*, coming from the side of the neck, unites with the vertebral vein near its termination, in the back part of the subclavian, or sometimes in the axillary vein.

* Haller, Icon. † Walter.

OF THE VEINS OF THE ARM.

The veins of the arm are in two sets, the venæ comites ; and the external or sub-cutaneous veins, being those without the fascia, and not subject to the compression of the muscles. Of these, the latter are the more important, and require a particular description.

On the palm of the hand, the veins are few and small, because they are there subject to compression in the frequent grasping of the hand ; but on the back of the hands and fingers, the veins are numerous and large. The veins, creeping along the fingers, make a remarkable inosculation on the back of the first phalanges, and then, passing in the interstices of the knuckles, form a great and irregular plexus on the back of the hand* : the principal branch of which sometimes takes the form of an arch.†

The plexus of veins from the back of the hand is continued over the back of the wrist : when some of the larger branches, after playing over the heads of the radius and ulna, take a course, the one on the lower, and the other over the upper edge of the arm, whilst the back of the arm is left without any remarkable veins taking their course there.

The veins on the back of the hand have nerves intermingling with them, viz. branches of the ulnar nerve, and the extreme branches of the muscular spiral nerve ; so that it is a great mistake to suppose that bleeding in the back of the hand might be substituted with advantage for the common operation in the bend of the arm, in order to avoid pricking the nerves.

VENA CEPHALICA.—The vein of the back of the thumb running into a trunk, which takes a course over the outside of the wrist, is called CEPHALICA POLLICIS.

From this vein and the division of the plexus of the back of the hand, a considerable trunk is generally formed, which takes its course on the radial edge of the arm, and is called CEPHALICA MINOR, or RADIALIS EXTERNA. This vein in its tract over the extensor radialis, and the supinator longus, has many lateral communications, particularly with the median vein.

This vein now joined by the median cephalic, and rising upon the outside of the humerus, becomes the GREAT CEPHALIC VEIN ; and it passes, first betwixt the biceps and triceps brachii, and then betwixt the deltoides and pectoralis major muscles. In this course it is joined by several small cutaneous branches, which play over the belly of the biceps muscle, and communicate with the basilic vein ; a little below the external condyle of the os humeri, the cephalic vein detaches a branch which ascends betwixt the brachialis internus and supinator longus, and which afterwards forms inosculations with the basilic vein, on the back of the arm.

The great cephalic vein, passing up betwixt the tendons of the pectoralis major and the deltoid muscles, sinks into the axilla and joins the axillary vein.

* *Plexus dorsalis manus.* † *Arcus venosus dorsalis.*

VENA BASILICA.* We trace the origin of the basilic vein from those veins which, being continued from the plexus, on the back of the hand, take their course over the lower head of the ulna. (A conspicuous branch of these veins, from the little finger, was called SALVATELLA† by the ancients.) From this origin, the basilic vein takes a spiral course on the ulnar edge of the fore-arm, sometimes in one great trunk, oftener in two, sometimes in a plexus of veins; here it may be called ULNARIS SUPERFICIALIS, or CUBITALIS INTERNA. This vein, now rising before the inner condyle of the humerus, passes on the inner margin of the biceps flexor muscle; here it forms very free and numerous connections with the internal or brachial vein, the satellites and cephalica; still passing up, it sinks by the outside of the tendon of the pectoral muscle, and joins the axillary vein.

The great basilic vein, or the great trunk, after it has ascended above the elbow, and received the median basilic, is joined by several deep branches of veins; as those which accompany the brachial artery, called satellites or comites, and a vein which is called profunda brachii; and still nearer its termination, it receives the addition of the *vena sub-humeralis*, or *articularis*, and the *venæ scapulares*, viz. those answering to the arteries of that name, and coming from under the scapula.

VENA MEDIANA MAJOR.‡—This is a vein which runs up the middle of the fore-arm, beginning from the plexus of veins, which play over the flexor tendons, and come from the ball of the thumb; it is very irregular, being sometimes double, and sometimes assuming the form of a plexus; often it is particularly short, and can be considered as a trunk only for a few inches as it approaches the bend of the arm; not unfrequently it is entirely wanting, and as if annihilated by the greater size of the branches of the cephalic or basilic veins. But for the most part, when this vein has ascended on the middle of the fore-arm, near to the bend of the arm, it divides; one branch passes obliquely outward, and joins the cephalic vein; the other inwards, and unites with the basilic vein; the first is of course the MEDIAN CEPHALIC VEIN§, the second the MEDIAN BASILIC VEIN.

These are the two branches which the surgeon most commonly selects for bleeding. Around the median cephalic the cutaneous nerves play more profusely, and under the median basilic vein the humeral artery passes. It is by the awkward plunging of the lancet into the median basilic, that the country bleeder sometimes produces the aneurism of the artery; but the dreadful symptoms following the pricking of the nerve are more frequently produced by bleeding in the median cephalic; cases however occur of the pricking of the nerves while bleeding in the median basilic vein.

AXILLARY VEIN.—The trunk of the veins of the arm passes through the axilla, until it arrives betwixt the first rib and clavicle, under the name of axillaris. Here lying by the side of the artery, it receives many muscular branches from the flesh of the shoulder, the external

* *Brachialis.* The ancients termed the basilic vein of the right arm, the vein of the liver, or *vena hepatica brachii*, and that of the left, the *vena splenica brachii.*

† *Salvatella quasi Salvator*, being opened as a sovereign remedy in Melancholia.

‡ *Vena media; vena superficialis communis. Fabricii fig. brachii viva.*

§ *Portio cephalica, A. B. loc. cit.*

and internal scapular veins, and the thoracic veins ; in general where it passes by the head of the humerus it receives the cephalic vein.

Subclavian veins.—The axillary vein, continuing its progress over the first rib, becomes the subclavian vein, and is joined by the external jugular vein. It then takes a direction downward, and being joined by the great internal jugular vein, and having received the trunk of the absorbent system just at the angle of the meeting with the great jugular vein, it terminates in the superior cava. On the right side the subclavian vein is shorter, and descends more directly ; on the left it is longer, but still its direction is downward and across the upper part of the chest ; passing before the trachea and the branches of the arch of the aorta, it joins the subclavian of the right side, and together they form the superior cava. Besides the jugular veins, the left subclavian vein receives these : a vein from the shoulder and lower part of the neck ; the vertebral vein ; with some lesser plexus of veins descending from the neck, and the thyroid veins. From below they receive the lesser internal thoracic veins, and the mammariæ.*

THE SUPERIOR VENA CAVA, THE VENA AZYGOS, AND LESSER VEINS OF THE THORAX.

The superior vena cava is the trunk of all the veins of the head, neck, arms, and of the parts in the thorax ; soon after it is formed by the union of the subclavian veins, it is joined by the vena azygos, and receiving the internal mammary veins, and the venæ thymicæ and pericardiac, and the intercostal and bronchial veins, it descends into the pericardium, and dilates or opens into the right sinus or auricle.

Vena azygos.† The vena azygos is the principal vein of the thorax, and chiefly of the walls of the thorax. It is observed to take its origin upon the vertebræ of the loins from some of the lumbar veins, or by inosculations with the renal, spermatic, or lesser branches of the abdominal cava, receiving the first and second lumbar veins, as in its ascent in the thorax, it receives the intercostal veins on either side‡ ; ascending betwixt the crura of the diaphragm, and by the side of the aorta, it sometimes receives the lower phrenic veins. In the thorax lying on the right side of the bodies of the vertebræ, and before the intercostal arteries, it receives the bronchial veins from the root of the lungs, and from the trachea it receives the veins of the posterior mediastinum and œsophagus ; through the intercostal veins, it communicates with the external and internal mammary veins, and with the venal circles of the spinal marrow.

Upon the third vertebra, the azygos vein separates from the spine, and after forming an arch, and bending round the root of the lungs, it opens into the superior cava, just where it is about to enter the pericardium. And here, where it opens into the great vein, it is guarded by a valve.

* *Haller, Icon. Anatomic. Corporis humani Fasciculus iii. tab. arter. Pectoris.*

† *Sine pari.*

‡ We except some of the veins from the interstices of the higher ribs, particularly on the right side, which enter the subclavian vein.

This vein, however, like most others, has considerable variety, and does not always merit the name of azygos, for sometimes it is double, a division ascending on the left side of the spine, and uniting with the branch of the other side, just as it is about to enter into the superior cava.

Of THE LESSER VEINS IN THE THORAX.—The VENÆ MAMMARIÆ take a course by the side of the internal mammary artery, and require no description. Like the arteries, they spread their branches on the muscles of the belly, and communicate with the diaphragmatic and lumbar and epigastric veins. The left mammary vein terminates in the left subclavian vein, the right in the superior vena cava.

The VENÆ THYMICÆ enter, either into the union of the subclavian veins, or they enter into the guttural veins, or the internal mammary veins.

The PERICARDIAC VEINS gather their branches from the pericardium, from the aorta, trachea, and lymphatic glands; they send down branches by the side of the phrenic nerve, which inosculate with the veins of the diaphragm; they enter the internal mammary vein, or the superior cava, or join the right subclavian near its termination.

The SUPERIOR INTERCOSTAL VEINS.—The right and left intercostal veins differ in their size and distribution; the right is small, and receives only one or two of the upper intercostal veins, which do not enter into the azygos vein. The vein of the left side begins even so low as the interstice of the seventh rib; it receives branches from the veins of the pleura, pericardium, and lungs, (viz. the bronchial veins,) and from the veins of the œsophagus, and they enter the subclavian veins.

OF THE VEINS WHICH UNITE TO FORM THE INFERIOR VENA CAVA.

The inferior vena cava receives the veins of the lower extremities, the hypogastric and abdominal veins, and the veins of the viscera of the abdomen; but those of the spleen, and the membraneous contents of the abdomen, are received by it only indirectly, and through the circulation of the liver.

OF THE VEINS OF THE LEG AND THIGH.

We have observed that the veins of the extremities are in two sets; the deep and the superficial. In the leg and thigh, the deep seated veins accompany the arteries, and receive the same name: the cutaneous veins may be included under the name saphena major and minor, and their branches.

SAPHENA MAJOR.*—A large and beautiful plexus of veins is formed on the fore part of the foot, by veins coming from the back of the toes, and outside of the foot. Two principal veins arise from the arch which these form: one takes the course behind the inner ancle, and is the saphena major; the other passes over the outer ancle, and forms the saphena minor.

The great saphena may be traced from the great toe, from the inside

* *Saphena magna interna.*

of the foot, and behind the ancle: it receives one or two branches from the sole of the foot. Sometimes the principal branch passes behind the lower head of the tibia, sometimes before it, or it forms circles here. a little above the ancle a vein from the middle of the metatarsal arch comes obliquely over the tendon of the tibialis anticus, and joins it.

The saphena, now a considerable trunk, runs up the leg, before the inner margin of the belly of the gastrocnemius muscle, and on the inner ridge of the tibia. In this course, it receives numerous cutaneous branches, and backward, over the belly of the muscles, it forms inosculations with the lesser saphena. From the inside of the leg the trunk ascends on the inside of the knee, where it receives several branches, coming round the joint, and over the head of the tibia. Now passing somewhat obliquely, it ascends upon the thigh, and at the same time turns from the inside to the fore part of the thigh. In the thigh the great saphena receives many branches, and is not always a single vein: for sometimes the branches collecting form a small trunk, which runs collateral to the greater vein; these join in the groin. In all its course the saphena vein is superficial, and lies imbedded in the cutaneous fat; with but a very slight and imperfect aponeurosis inclosing it; while it is external to the proper fascia of the leg and thigh. As it ascends upon the thigh, however, it does not dive suddenly under the fascia; but is gradually enveloped and embraced by the condensed cellular membrane and fascia, until it finally terminates in the crural vein.

When it was more the practice than at present to bleed in the ancle, the saphena major was the vein selected: but as in all the course of the vein, from the great toe to the knee, it is connected with the nerve which bears its name, there are not wanting instances of those bad effects from pricking of this nerve, which not unfrequently follow the bleeding in the arm.

The surgeon has much to do with this long vein of the thigh, since it is more than any other vein subject to dilatation. By costiveness, principally, and straining at stool, the blood of the abdominal vein is pushed back upon the valves of the crural vein. They yield, or what is the same thing, the coats yield; the diameter of the vein is increased; the valves do not reach across the vein; their action is lost; the column of blood is thus extended, and its pressure increases. The consequence of this is a painful distension of the veins of the thigh and leg.

In consequence of the rapid distention of the veins of the thigh in this manner, I have repeatedly seen suppurations on the thigh, a complaint not described or understood. The more common consequence, however, is a varicose enlargement of the veins of the leg: and accompanying this source of debility in the circulation of the limb, an ulcer near the ancle, and depending on the state of saphena.

Saphena minor.*—This vein arises from the plexus on the outside of the dorsum of the foot: it runs over the outer ancle, and above the fascia, covering the tendons of the peronæi muscles. Here receiving many branches, and forming frequent deep inosculations, it mounts on the outside of the vagina or fascia, which covers the back of the leg, but gradually becoming deeper, it is found under the fascia, on the calf of

* *Vena saphena parva externa.*

the leg, and arriving betwixt the hamstring tendons, it sinks into the popliteal hollow, terminating in the popliteal vein.

The lesser saphena vein, like the anterior one, is subject to become varicose; and when we imagine that the varicose state of the limb, and the consequent ulceration, is depending on the long anterior vein, it may be a consequence of the posterior and lesser saphena.

The other veins of the lower extremity, which accompany the arteries in their course, need little description.

Anterior tibial veins.—The veins accompanying the anterior tibial artery form many inosculations, and, when minutely injected, almost conceal the artery. They are the anterior tibial veins, and only unite into a trunk, where, perforating the interosseous ligament, it joins the popliteal vein.

Posterior tibial veins.—In the sole of the foot we have the external and internal plantar veins, which, uniting into trunks, accompany the artery behind the inner ancle. In its course betwixt the solæus and the tibialis posticus muscles, it cannot be called the posterior tibial vein; for it is a mere net-work of veins surrounding the posterior tibial artery. It receives, near its termination, a branch called suralis, from the gastrocnemii and solæus: it terminates in the popliteal vein.

The venæ peroneæ are the venæ comites of the fibular artery, and are two or three in number. All these veins have free inosculations with each other.

The popliteal vein.—This vein is formed by the three divisions of deep veins accompanying the arteries of the leg and the saphena minor. It lies more superficial than the artery, and seems to cling round it. As it ascends, however, it twists round the artery, the artery being nearest the bone—a little above the joint it receives the lesser saphena. It then perforates the tendon of the triceps, comes to the fore part of the thigh, still united to the artery, and lying posterior to it: it is now the crural vein. As it ascends, it gets from behind the artery, so that in the groin it lies nearer the pubes than the artery does: opposite the trochanter minor it receives the internal and external circumflex veins, and the vena profunda femoris. About an inch below Poupart's ligament the crural vein receives the saphena major, and the small external pubic veins, and finally, the veins which descend from the integuments of the belly.

The veins of the lower extremity are very strong in their coats, and indeed equal the arteries in the thickness of their coats: for example, in an amputation, it will not be possible to distinguish the vein from the artery upon the face of the stump, unless by their relative position. These veins do, in fact, sustain a long column of blood, and great pressure consequently; and so powerful is this pressure, that when a varicose vein bursts in the ancle, some pounds of blood are suddenly lost. A rupture or wound of a vein in the thigh, has an effect like an artery in sending the blood abroad into the limb.

External iliac vein.—The femoral vein lying on the inside of the artery, or nearer the pubes, enters the abdomen under the femoral ligament, and passing by the side of the psoas muscle becomes the external iliac vein. It receives several lesser veins just within the ligament, par-

ticularly the epigastric vein from the muscles of the belly, and the veins accompanying the arteria circumflexa ilii.

Veins of the pelvis.—The veins of the integuments of the penis join the superficial veins, which are called pudicæ externæ, and fall into the crural vein in the groin. The proper veins of the cavernous body of the penis, and of the spongy body of the urethra, form the vena dorsalis or vena ipsius penis. This is a large vein which runs down betwixt the dorsum of the penis and the ossa pubis. This vein having made good its course into the pelvis, is joined by a large plexus which is around the prostate gland and the vesiculæ seminales in the male. Here, indeed, the veins are so large, and so irregular, as to deserve the name of sinuses. How much blood they contain is known to the lithotomist, since they are cut in that operation. These prostatic veins are joined by the venæ vesicales. These unite to the branches collateral to the pudicæ, finally to the veins returning from the gluteal artery. These form the internal iliac veins or hypogastric vein, ascending from the pelvis, join the external iliac vein coming from the thigh, and form the common iliac vein.

The common iliac veins.—The common iliac vein begins at the sacro-iliac symphisis, and runs up upon the sacrum to join its fellow of the other side opposite to the cartilage, which joins the fourth and fifth vertebræ of the loins.

Vena cava abdominalis.*—A little lower than the bifurcation of the aorta, the right and left common iliac veins unite, and by this union they form the vena cava. This vein ascends upon the right of the aorta. It receives fewer branches than would naturally be imagined, because the veins of the viscera take their course by the vena portæ into the liver. It receives the lumbar veins, four on each side, the spermatic veins, the renal, supra-renal, and phrenic veins. Passing upward, it is received into its appropriate fossa in the liver, and seceding a little from the spine it receives the venæ cavæ hepaticæ, and perforates the diaphragm; entering the pericardium, it expands into the great sinus, or right auricle of the heart.†

Renal veins.‡—These veins are less irregular than the arteries of the kidney, which relation of the veins and arteries is uncommon. From the relative situation of the kidneys to the cava, it is evident that the right vein must be short; the left comparatively longer, and taking a course from the kidney over the aorta.§

Supra-renal veins.—These little veins are like the arteries in their course. The right one enters sometimes into the vena cava, sometimes into the renal vein. The left sometimes receives the phrenic vein of that side and enters into the renal vein.

Spermatic veins.—The veins of the testicles return from the minute extremities of the spermatic artery, distributed in the body of the gland and in the epidydimis, one beautiful and tortuous artery may be seen upon the tunica albuginea testis. As these veins reach the cord they

* *Vena Cava inferior.*

† *Venæ Cavæ lusus. Act. Petrop.* tom. xii. p. 262. *Sandifort Thes.* vol. i. p. 348.

‡ Emulgent veins.

§ The Renal veins, however, sometimes vary in their number, the right being double or triple, the left even sometimes in four branches.

become very tortuous, and, encircling the convolution of the spermatic artery, form a thick vascular body. They are joined by the vein of the epidydimis as they ascend. The higher these vessels are, the nearer to the ring, the less convoluted they are, which makes the cord of a pyramidal shape. This is most remarkable in brutes; and in them chiefly have these vessels got the name of CORPUS PYRAMIDALE and PAMPINIFORME.*

The spermatic vein, before it enters the abdomen, has collected the principal branches, and is fortified with valves. These valves, however, sometimes lose their office in consequence of dilatation of the veins, and then comes a very unpleasant varicose swelling of the spermatic cord, which is attended with a gravitating pain, and some degree of weakness of the gland.

The spermatic vein passing the spermatic passage, and forming a very considerable part of the whole cord, enters the abdomen, but still behind the peritonæum. Here coursing round the loins, it gathers branches from the fat of the kidney, the ureter, &c. The right vein is generally double, the left single; the one joins the cava, the other the emulgent vein.

From the point where the crural vein terminates in the external iliac vein, up to the heart, there is no valve. This circumstance of there being no valves in the veins within the abdomen proves that they are useful only to guard against the effects of external and muscular pressure, and that where the veins are safe against partial pressure they require no valves.

This circumstance of there being no valves on the lower cava and its branches makes the wounds of these vessels as full of danger as the wounds of the great arteries. I have known a wound of the external iliac vein prove fatal by a gush of blood, as formidable as if it had come from the artery, because it descended unobstructed from the heart.

I must refer to the anatomy of the abdominal viscera for the description of the peculiarities in the circulation in the liver.

It is sufficient that at present I remind the student that the blood of the stomach and spleen, the small and great intestines, does not fall into the cava. The veins from these floating viscera, as they have been sometimes called, form a trunk, which running obliquely across the abdomen, and entering the liver, is called VENA PORTÆ. The VENÆ CAVÆ HEPATICÆ are two large veins which come out of the liver, and which join the vena cava just as it is passing the diaphragm.

OF THE LYMPHATIC AND LACTEAL SYSTEMS OF VESSELS.

WE have understood that the red blood circulates in the body, through the arteries and veins, and that these vessels have a direct communica-

* Pampiniformis, *i. e.* resembling the tendrils of the veins. *Icon. Anatomic. Corporis humani Fasciculus iii. tab. arter. Pectoris.*

tion at their extremities by inosculation: that although these vessels lie parallel to each other, and extend from the heart to the remotest part of the body, yet the blood is said to pass through the circulation, because it is transmitted from the arteries into the veins, and so back to the heart. In this transmission of the blood through continuous tubes, there is in the coats of the vessels an alternation of contraction and relaxation which impels it forward. But besides these arteries and veins carrying the red blood through the body, there are other pellucid vessels, more remote in their connexion with what is generally called the circulating system, and which neither receive an impulse from the heart, nor exhibit any sort of pulsation by their proper force.

OF THE CAPILLARY VESSELS, AND THE PHENOMENA PRESENTED BY THE MICROSCPE.

The capillary vessels are those extreme branches which are as minute as hairs; but this, though the literal, is not the general meaning of the term. By capillary vessels is rather understood those branches in which the changes are wrought from the blood, and which are either so minute as not to allow the promiscuous flow of the particles of the blood, or possessed of such a degree of irritability and appetency, as only to allow certain parts of that fluid to be transmitted.

It is proved, that in the living body there is no exudation; but no sooner is the animal dead, than the fluids exude from the vessels, the secretions pass through the coats of those receptacles which formerly contained them, and one part partakes of the colour of another which is contiguous. From this fact, we are led to think that a property exists in the living fibre, which repels the fluids. Admitting this, it is very natural to suppose that the fibres, and more particularly the vessels in the capillary texture of each organ, possess sensibility, which has its relations to the fluids passing through them, or to be secreted from them.

The most beautiful phenomenon may be seen by the aid of the microscope, in the circulation of the blood, that is, the transmission of the blood from the arteries into the veins. When the web betwixt the toes of a frog is submitted to the microscope, the eye at first discovers only a confused motion of particles. But by a steady continuance of the observation, we are soon able to observe the motion of the red particles of the blood. We do not discover the coats of the vessels, but conclude that they exist, from the confined and certain course of the particles which are in motion. We distinguish the arteries by the rapidity of the particles passing through them in *single files*, and pursuing these particles, they are observed to turn suddenly into larger vessels. These vessels, by the number and slower motion, and altered direction of the red globules, are recognized to be the veins. When the animal is disturbed there is a general acceleration of the motion of the blood in the small vessels. When the web or membrane is pricked and irritated, (as with salt and Cayenne pepper in solution upon a needle,) the motion of the particles in the arteries is accelerated in a very singular manner; if the excitement to inflammation be continued, the veins are seen to enlarge, and an accumulation of red particles takes place in them by which they are visibly distended. These accumulated particles are urged for-

ward with a difficulty which seems to be occasioned by the attraction of the fluid to the sides of the coats.

It is remarkable, that while we admire this proof of the circulation, we see the influence of the heart's action upon the blood in these minute veins; for at each pulsation of the heart the red globules are sent forward, being stationary, or recoiling during the diastole.

During the disturbance of the circulation of the part by the application of stimulus, there seems to be a certain attraction or cohesiveness betwixt the sides of the vessels and the red globules, which occasions the remora and accumulation of the red globules. The same was the consequence of cutting the vein across, for the blood, instead of flowing from the cut, became arrested in the vessel.

Since we see that in an inflammatory state the pellucid veins transmit red blood, and that this red blood must be supplied by the serous arteries; then it is proved that answering to the pellucid arteries (in their natural state) there are pellucid veins. We acquiesce, therefore, in the opinion that supposes both the arteries and veins to have pellucid capillary branches answering to each other, collateral to the larger and more evident anastomoses of their red extremities. These anastomosing branches of the arteries and veins in which the red blood is seen to circulate, perpetuate the flow of the greater part of the blood back to the heart, while the several secretions are performed in the capillary vessels; but there is no reason to suppose that the fluids sent from the arteries into these pellucid capillary vessels are all poured out in form of secretions: part returns into the extremities of the circulating veins. The secreted fluids and solids are either carried away by ducts into their receptacles, or thrown out from the body: while those fluids, which are exuded on the cellular membrane and cavities, are re-absorbed by the system of absorbing lymphatics.

We say then, that arteries terminate, first, in red veins, which is proved by the microscope, and by mercurial and other injections; secondly, in glands; thirdly, in cells receiving red blood; fourthly, in lymphatic veins; fifthly, in exhalents, which pour their fluids into the cellular membrane, cavities, joints, &c., and which fluid is taken up by the valvular lymphatic absorbents.

But these absorbent vessels, of which we are now to treat under the division of lymphatics, do also perform a circulation, in as much as they convey back to the centre of the system the fluids which have been thrown out from the extremities of the arteries. But as these lymphatic vessels are not continued from the extremities of the arteries as the red veins are, as they imbibe the fluids, which have been thrown out of the other system of vessels, their fluid contents cannot be conveyed through them by the force of the heart and arteries; these vessels must be peculiar in having powers within themselves, first of absorbing and then of propelling their fluid onward to the heart. Neither can they be said to be circulating vessels according to the use of that term, for although they carry the lymph back to the heart, yet the continuity of the vessels is broken; they are not continuous with the extremities of the arteries.

The LACTEALS are vessels which, distributed to the intestines, absorb and convey into the system the milky opaque fluid which is generated in the intestines by the process of digestion.

The common property of absorption in the lymphatics, absorbents, and lacteals, and their being connected with the same trunk, occasions their being considered as one system of vessels; yet looking upon the general economy of the living body, we find them ministering to very different purposes. The one branch of the system, the lymphatics, conveys the waste of the body again into the circulating system. The lacteal vessels, on the contrary, are those vessels, which, opening upon the inner surface of the intestines, receive into them the nutritious fluids prepared by the organs of digestion, and suited to supply the incessant waste and destruction of the solid and fluid parts of our frame, which have been absorbed and carried away by the lymphatics. Following this simple view, although the absorbent system be commonly divided into the thoracic duct, lymphatics, lacteals, and glandular apparatus attached to them, I shall throw the present section into the division of the lymphatics and of the lacteals.

OF THE LYMPHATIC SYSTEM IN PARTICULAR.

The lymphatic vessels are tubes whose coats are perfectly pellucid, having a remarkable power of contraction, which causes them to shrink and disappear, so as to render it difficult to demonstrate them. Indeed they are only to be observed by an eye accustomed to make lymphatic injections. They are called LYMPHATICS, or DUCTUS AQUOSI, from their transmitting a fluid colourless as water. When they are distended with their fluids, they show that they possess a very distinct character from the other vessels. They are irregularly distended, knotty, and sometimes like a chain of beads, or little irregular vesicles connected together. This irregularity is owing to their numerous valves, which are semi-lunar membranes, like those of the veins, hung across their cavities, so as to catch and interrupt the refluent lymph.* They say, in general, that in the space of an inch the lymphatic vessel has three or four pairs of valves. But this bears no certain proportion; for as these vessels run where they are exposed to occasional compression from the surrounding parts, or bear the weight of a high column of fluid, their valves are more frequent. The lymphatics are improperly called cylindrical tubes, since they are irregular from their valves, their branching, and frequent communications. The coats of the lymphatic vessels are the strongest of any in the body; for although extremely thin and pellucid, they give resistance to distention beyond a certain point, and bear a column of mercury which would burst through the valves of veins, and tear the coats of arteries. If there be a muscular coat, and no one ever denied the muscularity of the lymphatics, then we may reckon three coats: First, the inner coat, which is the continuation of the inner tunic of the veins, as may be observed in the opening of the thoracic duct into the left subclavian and left jugular veins. It is smooth and polished, forms duplicatures or valves, and prevents the transudation of their fluids: it is connected by cellular membranes to the middle coat. Secondly, the muscular or middle coat, which consists chiefly of muscular fibres, which, according to Sheldon, run in every possible

* *Ruyschii Dilucidatio Valvularum.* Vet. Oper. vol. i.

direction, though the greater number take the circular direction. And, lastly, the outer coat, which is connected with the general investing cellular membrane. As the inner coat must chiefly form the valves, and as the valves possess a very remarkable power of resisting the column of mercury, I conceive that the inner coat is that on which the strength and resistance to distention of the lymphatics depend, though it has been said that it is to the outer coat that they owe this property. The muscularity of these vessels is rather inferred than proved: it is inferred from the unassisted action which they have to perform in pressing the absorbed fluids onward to the heart. Nevertheless we sometimes see the lymphatics of the lower extremities of a colour so red, that we may say their muscularity is demonstrable.

The lymphatics seem to possess little elasticity; when they are blown into, they rise with the slightest force, and remain distended, although the passage of the air forward be uninterrupted; whereas had they considerable elasticity, they would contract and disappear. Indeed, when empty, in the dead body they may be rather said to be collapsed than contracted. Although the lymphatics can be distended with the slightest inflations, yet when distended, as we have already observed, they firmly resist further dilatation. This is a quality necessary to their valvular structure, for if they were elastic beyond this degree of dilatation, the calibre of the vessel would be occasionally so enlarged as to render the valves incapable of meeting, and consequently of preventing the retrograde movement of the fluids.

Indeed they appear sometimes to suffer this kind of enlargement or distention, for we occasionally find that the mercury runs backward along the vessels, contrary to the proper course of fluids in them.

OF THE GLANDS OF THE ABSORBENT SYSTEM.

Every where throughout the human body and viscera, betwixt the extreme branches of the absorbent system and the trunk, glandular bodies are interposed. Though these glands be of various forms, they are generally of an oval shape, and they vary in size from the twentieth part of an inch to a full inch in diameter. Sometimes they are segregated, sometimes accumulated and clustered together. The colour of those bodies is various in the several parts of the body: in young animals they are redder, and become pale only with age. They are redder and stronger in the outer parts of the body, as in the thigh, axilla, &c., less so within the abdomen and thorax. 2. The latter will not bear so high a column of mercury as the former. The mesenteric glands are said to disappear in old age.* They certainly diminish very remarkably.

It would appear that the glands of this system are of more importance to young animals than to adults. In the fœtus and in children, the lacteal and lymphatic glands are exceedingly numerous; but they shrink with old age. In the fœtus, they can be of no very essential use; they are then rather in a state of preparation for the actions necessary in infancy and youth. It is during infancy and youth that they are most liable to disease, and seem more irritable and ready to inflame,

* By Ruysch, Morgagni, Haller, Sheldon.

especially when they are placed superficially. About the age of fourteen or fifteen this disposition is changed, which is commonly said to proceed from the increased vigour of the constitution, and the change which then takes place on the organs of generation. It is rather to be attributed, however, to the diminution of irritability and activity of the vessels of the glands at this age, for, as we have said, the glands are now smaller and paler. We may further observe, that the lymphatic glands, even in the scrofulous diseases, are seldom primarily affected: they partake of diseased action from an impression on the surface of the body, or from an affection of the intestines, or from the absorption of matter. The structure of these glands has not been satisfactorily investigated. There is at least some obscurity over this subject. Some anatomists have said, that they consisted of the convoluted absorbent vessels; others, that they are of a cellular structure. When they affirm that these cells are totally distinct from the lymphatic vessels, it is not so easy to understand them: for cells communicating with each other, and into which the lymphatic vessels enter, are very much the same with a series of convoluted, varicose, and irregularly dilated vessels. If we could dissect this series of cells, as Haller did the vesiculæ seminales, we should have represented to us the appearance of a convoluted varicose vessel.

There is a coat of cellular membrane which surrounds the glands. This coat is pervaded by a peculiar fluid, which has given rise to some speculation. It is observed chiefly in young animals, and is for the most part, though not always, white and milky, and in the glands of the lungs it is of a blackish colour. This is the fluid which, having globules in it, was supposed by Mr. Hewson to be the first stage of the formation of the red globules of the blood. It is distinct from the absorbed fluids, and is a secretion from the arteries. Physiologists have not determined the nature or use of this fluid. The arteries and veins which supply the lymphatic glands differ in their course from those branches which are supplying the common surrounding parts. The artery takes a long circuitous course, and twists and turns before entering into the gland.

At present there seems no better hypothesis to be offered regarding the use of the lymphatic and lacteal glands, than that they serve to check, control, and measure the flow of the absorbed fluids into the mass of the blood: without them it appears to me probable that at one time the lymph, returning from the body, or at another time the chyle, might flow too rapidly, and in a disproportioned quantity, into the veins and heart. But by the check which the glands impose upon this flow, giving a remora, and serving as receptacles of the absorbed fluids, the fluids are poured with a more uniform and constant flow upon the heart.

As to the opinion, that these glands prevent poisons entering into the system, it cannot be sustained. Is it really so? Have they this effect? And the answer must be, No! On the contrary, they seem the first to inflame, and hence to propagate bad action, rather than to prevent the contamination of the system.

ORIGIN OF THE LYMPHATICS, AND OF THE DOCTRINES OF ABSORPTION.

The lymphatics, forming a system of absorbents, we might say, in general, that they take up all the fluids which have been thrown out upon the surfaces of the body. Thus they arise from the pores of the skin; from the surface of the cavities and viscera, which are covered by the pleura and peritonæum; from the cells of the interstitial and adipose membrane: from all the ducts and cavities of the body. This is the use assigned to this system of vessels; but whether they are the only system of absorbents; whether they carry away all the parts of the system, fluids, and solids; whether they absorb the muscles, membranes, bones, tendons, &c. of which the solid body consists, as well as the secreted fluids, is a question requiring examination: for there is much presumed; a great deal of very loose reasoning brought forward in support of lymphatic absorption,—and this much I must say, although I do not object to the doctrine of absorption by lymphatics. We shall first examine the proofs of the lymphatics being the vessels which absorb the fluids of the cavities and surfaces of the body. The animal machine universally partakes of motion. A principal provision for this mobility of parts is the looseness of the cellular membrane which every where pervades the body, and supports the vessels, and connects the several parts. This interstitial membrane is elastic, and being cellular, to allow of motion, its surface is bedewed with serous exudation. This fluid is perpetually passing from the extremities or sides of the lymphatic arteries or capillaries into the cellular membrane, and upon all the cavities of the body. The fluid extravasated is called serum, and some have supposed that it passes through inorganized pores, an expression that is not very intelligible; but if by this is meant (as has sometimes been explained) "accidental pores" in the sides of the vessels, it is a supposition quite improbable and unlikely.* The pores or vessels from which this fluid exudes are called exhalent; and their action is no doubt as completely secretion as that which produces the fluids, which in our wisdom we call more perfect secretions.

That the lymphatics take up the fluids thrown out in the cavities of the body, as the abdomen, thorax, pericardium, &c. there is what nearly amounts to an absolute proof in comparing the fluids of those cavities with that contained in the vessels; for by the experiments of Hewson it is found that if the fluid moistening the cavities be collected, it will form a jelly when exposed to the air, as the contents of the lymphatics do. Thus, if a lymphatic vessel be tied up in a living animal, and then opened so as to allow the fluid to flow into a cup, it will form a jelly like the coagulable lymph.† The fluid of cavities alters in animals diseased;

* Dr. Hunter supported this opinion, (Commentaries, p. 40.) viz. "that the fluids of cavities were collected by transudation, and not thrown out by exhalents;" an opinion which could only have arisen from not correcting the ideas received in making injections in the dead body by the phenomena of the living system. See *Hewson on the Lymphatic System*, chap. viii., where the opinion of inorganical filtering is successfully combated.—See also Cruickshanks.

† But, by disease, the fluids in the cavities and cellular membrane are altered. In dropsy, for example, the fluid of the abdomen loses the property of coagulating on mere

sometimes retaining its coagulability, and even acquiring stronger powers; sometimes losing it altogether. But, which is most essential to our present purpose, it has been observed, that whatever change takes place in the fluids of the cavities, the same is found to have taken place in the fluids of the lymphatics.

But the student naturally asks, How is the lymph taken into the lymphatic vessels? and here it must be confessed, there is too much field for conjecture.

It was thought formerly that the lymphatic arteries terminated in small pellucid veins: these veins carrying only the thinner, and refusing the red part of the blood, were called lymphatics. When the anatomist threw in his minute injection, and saw the coloured fluid return by the red veins, and the colourless fluid return by the lymphatics*, it was held as a sufficient proof of the accuracy of the preconceived notion, and tallied with the observations of Leewenhoeck, and the theory of Boerhaave.† When, however, anatomists more carefully examined the state of parts, they found that the lymphatics were not filled, unless the cellular membrane was previously injected by the extravasation of the fluid from the blood-vessels. Finding that this alleged experiment was really no proof of the anastomosis, and direct communication betwixt the extreme arteries and lymphatics, they conceived that it was a proof that these lymphatics took their rise from the cellular interstitial texture. Then injecting with mercury, they found that when the vessels burst, and the column suddenly descended, and the cellular membrane was filled, the mercury was seen to rise in the lymphatics. Following up this, they blew air, or injected various fluids directly into the cellular membrane, and by this means injected the lymphatics. Thus by an error, by an accidental effect of their injection, the minds of Drs. Hunter and Monro were opened to a freer discussion of the received opinions, and approved authorities. Soon, however, it was understood by those conversant with anatomy, that these accidental injections of the lymphatics did not prove the lymphatics to take their origin either from the cells or from the extreme arteries; but already this good effect, at least, was produced, that men's minds were excited to enquire after new facts, and to follow a new train of observation. It was now recollected, that a strict analogy and correspondence subsisted betwixt the lymphatics and lacteals; the proofs of the lacteals being absorbents were recalled to memory; new proofs of their being the sole absorbents of the intestines were brought forward; the nature of the fluids effused into the various cavities and cells of the body was attended to; and the conviction followed, that the most essential use of the lymphatic vessels was to serve as a system of

exposure; it comes to resemble more the serum of the blood: this were sufficient proof that the collection is not owing merely to the diminished absorption, but that there is a change of action in the vessels of the peritoneum, pleura, pericardium, &c. An inflammatory action of the vessels will throw out a fluid more coagulable, and which, in a high degree of action, will form a film of coagulable lymph or even pus on the surface. But in a state the reverse of inflammation, such, for example, as the debility following inflammation, a serous effusion will be poured out having little tendency to coagulate.

* It was probably Nuck who first injected the lymphatics from the arteries.

† See introduction to the account of the viscera.

absorbents to take up the fluids extravasated, or secreted, on the surfaces of membranes and cavities.

An additional proof of lymphatic absorption has been derived from the manner in which the venereal virus is received into the system. Venereal matter being allowed to lodge upon the delicate skin of the glans penis or preputium, causes an ulcer there. The matter of this ulcer is absorbed by the lymphatic of the part; an inflamed line is sometimes to be traced into the groin; and the lymphatic gland of the groin, receiving this absorbed matter, inflames and forms the bubo. Here, then, is a proof that the red veins do not absorb, and that lymphatics do: else why are they inflamed?—and why are the lymphatic glands inflamed to suppuration?

We must observe, however, that there is here by no means an absolute proof of absorption of venereal matter. Although we believe in the general system, we may hazard these queries: If this matter be absorbed, why is there no infection without ulcer (chancre) of the glans? If this ulcer be produced by absorption, how comes it that the constitution is not infected by the first absorption of the matter, and before it has formed an ulcer? Is it not probable that the irritation of the venereal matter, lodging on this vascular surface, and without being absorbed, causes a peculiar inflammation, the tendency of which is to form a pustule, and to produce matter similar to that which originally infected the part with the specific and peculiar action? Again it will be said, however the venereal pustule was originally produced, it appears evident that the absorption of this matter, the conveying of it along the lymphatic, inflames the vessel, and the next lymphatic gland into which it enters, receiving the venereal matter, inflames and suppurates, &c. But again, I choose to say, with every show of likelihood, that neither is this a proof of absorption; but that the lymphatic vessel being very irritable, and always receiving its stimulus to action from its extremities, it has partaken of the venereal inflammation; that this inflammation has been propagated to the gland; that, the gland being formed of the convoluted lymphatic vessels, the effect of this inflammatory action is there accumulated to so great a degree as to lead to suppuration. If a bubo in the groin were a consequence of absorption, to injure and inflame the mouth of the lymphatic would be the method to prevent it. But, on the contrary, to irritate a chancre is the means of producing bubo. If a chancre be indolent, although matter be formed in it, no bubo will be produced; but if the surgeon applies some corrosive dressing, which, instead of entirely destroying the diseased spot, inflames it, then will the gland in the groin sympathize and rise into a bubo. And further, that the disease is received into the constitution only in consequence of the system at large partaking of the irritation (a word which but imperfectly expresses the change) of the local action of vessels. Matter might be absorbed and taken into the constitution, and the disease propagated according to the common explanation; but, according to that offered here, there must be a primary and local disease, from which the general affection is propagated. If we are to take the inflammation and hardening of the lymphatics and axillary glands as a symptom of absorption from a diseased mamma, we must acknowledge the same proof in evidence of the veins absorbing. The lymphatics are more active, and

their activity depending on the state of their origins and extreme branches, they are more liable to inflammation than the veins; yet are the veins affected in a way that would, on this proof being admitted, prove them to be absorbents. We see how they enlarge around the diseased breast, become prominent and hard, and lose their softness and elasticity; how they show themselves on the surface of a white swelling, or on a cancerous tumour. But, as we would not say that this is a proof of absorption by the veins, neither is the proof unequivocal that there is absorption by the lymphatics. Again, a suppurating stump, with bad inflammation, will cause inflammation of the lymphatics and suppuration in the glands of the groin*; a proof of absorption of the matter of the stump; but do we not find that from such a stump the veins ascend, inflamed and suppurating, while sometimes a chain of abscesses is formed for a considerable extent? This, we can have no doubt, is the effect of the inflammation continued along the vessel; and is not the inflammation produced precisely in the same way in the lymphatic.

I found my opinion of the lymphatics being absorbents,—first, on the circumstance that their structure is adapted to this action; secondly, on the analogy between them and the lacteals, in which absorption is proved; thirdly and lastly, upon their continuing to receive and transmit their fluids, after the heart and arteries have ceased to beat, and the red blood to circulate: for then how can they act, but by their own powers? How can they receive fluids but by absorption? Finally, they exhibit a greater degree of irritability, and stronger principle of activity and tenacity of life, than the vessels which carry red blood.

OF THE ABSORPTION OF SOLIDS.

On examining the works which within the last fifty years have contributed to throw light on this subject, we are forced to acknowledge how necessary it is for that part of a systematic book of anatomy, which professes to treat of absorption, to take the form of a critical enquiry. When the absorption of the fluids in the cellular substance, or contained in the cavities, was universally assented to, physiologists did not make sufficient distinction betwixt the absorption of this fluid thrown out of the influence of the circulating vessels, and that matter which continued to be involved in the membranes and vessels, and which formed the solid part of our frame. It will readily be allowed, that the fluid thrown out upon the surfaces of the body and in the cells, might be absorbed without inferring that every part of the body, solids and fluids, were also taken up by the lymphatic absorbent vessels. But physiologists observing that the solid parts of the body were suffering perpetual change, that the whole body and the vessels themselves were formed, decomposed, and carried away, they hesitated not to attribute this to the deposition from the arteries, and the absorption by the lymphatics. This alternate destruction and renovation of parts, the perpetual change which the whole body suffers, has been universally acknowledged to be the operation of the lymphatic system, without any other proof than what is offered by a slight analogy.

* See Hunter's Commentaries.

There is proof that the interstitial fluids, and the fluid in the cavities, are imbibed by the absorbing mouths of the lymphatics on the surface of the membranes; but where is the similarity between this and the destruction of solid parts? It has been said that the absorbents eat down the solids, and nibble like the mouth of a worm! a mere conjecture, and most improbable. The solids are raised by the agency of the vessels on the chemical affinities of the circulating fluids. They must be resolved by a process, reducing them again to the state of fluids; or the secreting vessels throw out fluids which dissolve them; there must be an operation anterior to their absorption. From the comparative simplicity of the fluids of the circulating vessels, and in the absorbents, with the various compounds forming the solid and fluid mass of the body, we are authorised to conclude, that as from the blood the several secretions, solids, and fluids are formed, these fluids, before they are again taken into the active system of vessels, are resolved into their original simple and constituent parts. We are not then to look for the matter of the component parts of the body in the absorbing system of vessels more than in the blood, from which these parts were originally formed; nor are we at liberty to suppose that they are taken down by a process like eating or abrasion. I conceive that the absorption of the solids depends but in a certain degree on the agency of the absorbents; and that there must be a change in the aggregation of the matter previous to the absorption.

Mr. Hunter says that his conception of the matter is, that nature leaves little to chance; and that the whole operation of absorption is performed by an action in the mouths of the absorbents. Physiologists have laboured, he observes, to explain absorption on the principle of capillary attraction, because it was familiar; but as they were still under the necessity of supposing action in the vessels after the matter was absorbed, they might as well have carried this action to the mouths of these vessels.

We are surprised at the extravagant conclusion to which this idea has led Mr. Hunter. He proceeds to consider the many kinds of solids the lymphatics have to carry away, and the variety of mouths in different animals, suited to the great variety of substances they have to work upon, and then draws the conclusion, or leaves his reader to do so,—that not only are the mouths of the lymphatics calculated to absorb fluids, not only do they carry away the solids, but each vessel, according to the hardness and toughness of the material upon which it has to operate, has a mouth adapted for the work.

He admits that oil, fat, and earth of bones, had always been considered as subject to absorption; and that some other parts of the body, liable to waste, had been supposed to suffer by absorption; but that any solid part should be absorbed, he supposes to be entirely a new doctrine. Now, I think we may venture to affirm, that not only was it known that solid parts of the body were taken away during life; but that physiologists knew that every part of the living body was undergoing a perpetual decay and renovation.

Nay, we may venture further to say, that Mr. Hunter did not comprehend, in its full extent, the relation in which the secreting and absorbing vessels stand to each other. He is fond of calling the absorbents modellers,—"modellers of the original construction of the body,"—"modellers of the form of the body while growing."

Mr. Hunter could contemplate no change in the body during growth, decay, or disease, where there was an alteration of form or quantity of matter, without attributing it to the "modelling absorption." A bone cannot be removed without absorption; nor a part which is useless to the economy (as the alveoli of the teeth, the ductus arteriosus, the membrana pupillaris, the thymus gland,) diminished in size or totally carried away, without the absorbents being in action. This, he continues, is the only animal power capable of producing such effects; and, like all other operations of the machine, it arises from *stimulus* or irritation, &c. On the contrary, I conceive that the absorption of parts in the natural action of health or in disease, is not owing to increased stimulus, but often to a diminution of it.

Does it not strike us forcibly, that when a gland swells, and leeches and blisters are applied, and it subsides, this can be no means of exciting absorption; that when pressure is made on a part, and that part is absorbed, this is a strange way of stimulating? Or, when we bleed, is it not odd that this should give new power to the lymphatic system? For these are the means of giving a counter irritation, and of suppressing action.

According to Mr. Hunter's ideas, the lymphatics do nothing without forethought and intention: when they absorb, it is because they have found the parts useless in the economy. He has carried this notion so far, that he does not only speak of the absorption of the thymus gland, membrana pupillaris, alveoli of the teeth, &c., but of the body in fever, as a consequence of its becoming useless when under disease!—The following may perhaps appear to be the more natural supposition.

In a living body we may observe the agency of the nervous, vascular, and absorbing systems: and the phenomena of life are not to be attributed to any one, but to the whole of these. We must also observe, that life, or the mutual action of parts producing the phenomena of life, is proceeding from excitement, and as in the whole system, so in the individual parts of the body, the healthy action depends on the influence of this excitement to action. The tendency of the growth of the body to peculiar forms, and the increase of parts in disease are produced by it. It acts upon the vascular system in disease, by producing increased action and secretion; as a muscle, in the use of frequent and strong action, will become more fleshy and vascular; as a gland will be excited to greater action and more profuse discharge, whilst it enlarges and swells up. When a part enlarges in consequence of the stimulus to increased action, whether arising from the natural law of the constitution, or from disease, it proceeds from the secreting vessels preponderating over the absorbent vessels. There is a deposition of matter which the latter are unable to take away. But diminish this action of the arteries, or take away their excitement, or cause an excitement of some neighbouring part, and thereby subdue their action, relieve them of their fulness, and the absorbents regain their proportioned actions, and the swelling subsides. The parts of the body which, in the natural changes from youth to age, are absorbed and carried away, are those in which there is no longer the stimulus to vigorous action, and of course the lymphatics overcome the power of the secreting vessels, and the part gradually diminishes, loses its apparent vascularity, loses its redness, and is at last totally absorbed.

And as the tooth of a child after lying long hid under the jaw, when it partakes of the stimulus to the action of its vessels, grows, and rises up, and the alveoli, partaking of this natural excitement also, form around it; so, when the tooth decays and falls out, the alveoli will also decay and be absorbed; because the moment these vessels have ceased to partake of the increased action, their absorbents, though acting with no greater powers than formerly, do yet so preponderate, that a gradual wasting is the consequence. Thus we have to consider, not the action of the absorbents merely, but the relations which their actions have to activity of the arteries.

I should conclude, that a part which has ceased to be of use in the economy, and is absorbed, has not been carried away by the stimulus applied to the modelling lymphatics, but in consequence of a want of the usual excitement of the arteries to action by a decrease of their action, and consequent deficiency of secretion. Since, in the natural body, every part holds its due form and proportionate size, by the balance established betwixt secretion and absorption, we have to decide whether its disappearance be an effect of the diminution of the former, or the increase of the latter action. We have to enquire whether the arterial system which secretes, or the lymphatics which absorb, are the most subject to influence. Now, when we see the pulsation of the arteries, and the colour and degree of vascularity of parts, continually varying upon the excitement: when, on the other hand, we see the lymphatics continuing their office unimpaired even after the death of the general system, and after the heart and arteries have ceased to move, we cannot be at a loss to determine which system of vessels is most subject to influence. Let us only suppose that the lymphatics are more permanent in their activity, least subject to change, and all difficulty is removed. Then we see how stimulating the arteries increases the growth, and how fluids are poured out in swellings, and how, by diminishing their activity at any time, the lymphatics, merely by the continuation of their usual action, produce an absorption and evident wasting.

Before we speak so familiarly as we do of stimulating the lymphatics, we ought to prove that it is possible to stimulate to absorption, in the same way in which we can demonstrate the effect of stimulus upon the arteries; and we should in the next place prove, that it is possible to stimulate the lymphatics, without influencing the arterial system in a similar degree.

We speak very commonly of stimulating the lymphatics to absorb by mercury; for example:—There may be a speck on the cornea, and calomel, or corrosive sublimate, is given to excite absorption. The practice is good, but surely this is the language of an erroneous theory. Suppose that we were rather to say, an inflammation from general disorder of the system, or of the viscera, has taken place, where it is most of all likely to take place; a course of mercury corrects this disposition; the cause removed, the inflammation subsides, and with it the speck. The same argument suits the phenomenon when a tumour or enlargement of a viscus is diminished, better than to say, that the mercury excites the lymphatics to the absorption of the tumour.

As to pressure causing absorption and producing the wasting of parts, I cannot agree with Mr. Hunter in supposing that the lymphatics are

here excited to action; but should rather infer that the nerves of the parts being benumbed, and the action of the arteries diminished, the lymphatics continue to do their office, while the arteries are prevented from depositing new matter.—For example, when we see a curvature of the spine, from a habitual inclination of the body to one side, and consequently greater pressure on the one side of the bodies of the vertebræ, it is natural, at first sight, to say, since the one side of the vertebræ is of its natural depth, and the other diminished, that the side which is deep has remained, but the other side has been absorbed; but, when we enquire further into the phenomenon which has taken place, we recollect that the matter of bone is undergoing a perpetual change, and that the matter of both sides of the vertebra is changed; we then comprehend that the pressure may not have excited the vessels to greater action so as to cause absorption, but that the pressure has prevented the deposition of new matter, when the old was taken away in the natural routine of the system.

Mr. Hunter has assigned five causes of absorption, which I conceive may be very naturally resolved into one.—These are, 1. parts being pressed; 2. parts being irritated; 3. parts being weakened; 4. parts being rendered useless; 5. parts becoming dead. Of the first we have already spoken. The second I should deny, unless when it resolves into the third; for irritation does not cause absorption, unless when it is to an extent sufficient to destroy the natural action and weaken the part. The third and fourth come under the effect of the loss of the natural and accustomed stimulus to action in the arterial system, which of course gives the balance in favour of the absorbents. Of the fifth we can have nothing to add illustrative of the living system.

A question is still undetermined; Do the lymphatics absorb the loose or free fluids secreted on the surfaces? Do they always take up what is offered to their mouths, in the manner that we know they do extravasated blood or bile? And is it the office of the veins to return the matter, which formed that part of the texture of animal bodies, which was never separated from the influence of the circulating system? What is this carbon, for example, which forms the distinction betwixt the venous blood and the arterial? Is not this carbon the waste of the animal frame returned by the veins, and is not this process of the nature of absorption? In short, there appears to me still an open field for enquiry, where an ingenious man may gain in future as much reputation as Dr. Hunter and Dr. Monro acquired by their investigations into lymphatic absorption.

OF THE COURSE OF THE LYMPHATICS.

The lymphatics, in their course and relation to the fascia and muscles of the extremities, bear a great analogy to the veins; for there are two sets or grand divisions,—the DEEP LYMPHATICS which accompany the arteries in their branchings amongst the muscles; and the SUPERFICIAL set which run a course external to the fascia.

OF THE FOOT, LEG, AND THIGH.—Even in the toes the same distinction of the origins of the lymphatics may be observed, as in the limb. For while a plexus covers the toes superficially, and runs up upon the foot with the veins, deeper branches accompany the arteries on the side

of the toes. When we observe the course and origins of the greater and lesser saphena vein, we cannot fail to understand the course of the several sets or divisions of the lymphatics of the foot and legs.

From the toes, dorsum, and edges of the foot, the lymphatics climb up the leg in four classes. 1. One takes a course from the root of the great toe and inside of the foot, over the tendons of the great toe and tibialis anticus tendon. It then passes on the inside of the tendon of the tibialis anticus muscle, and before the head of the tibia, following the principal branch of the great saphena vein; and then continues its course in company with the saphena to the inside of the knee. 2. There is at the same time a considerable number of lymphatics, taking their origin from nearly the same place, viz. the inside of the foot, and before the inner ancle; but they take a different course on the leg from the last class; for they pass behind the lower head of the tibia: they attach themselves to some branch of the saphena vein, and join the former set of vessels on the inside of the knee. From this they ascend superficially above the fascia to the glands of the groin. 3. From the outside of the foot there ascend several lymphatics; a division of which passes before the outer ancle and across the tibia to join the lymphatics, parasites of the great saphena vein, and here they sometimes form plexuses and contortions; others turn in behind the outer ancle, and join the branches accompanying the lesser saphena vein.

The lymphatics which turn round behind the outer ancle pass on the outside of the tendo Achillis; and, accompanying the lesser saphena vein, sink into the popliteal hollow. Here they unite with the lymphatics which have accompanied the several arteries of the leg and foot, and particularly the posterior tibial artery.

The deep lymphatics accompany the arteries, as we have said; and to inject them we should look for a very large vessel which is coming out from under the plantar aponeurosis to rise behind the inner ancle.

Popliteal glands.—The glands of the ham-string cavity are generally three in number, and very small. They receive some of the lymphatics, which pass with the posterior tibial artery and with the lesser saphena, but they are most apt to be disturbed and to swell when the interior of the knee-joint and bones are affected. They are very seldom diseased, which I attribute to their deep situation.

From the popliteal glands there ascend two large lymphatics, which accompany the popliteal artery and venæ comites, and ascend with the latter through the adductor magnus to the fore part of the thigh. They run irregularly, or form a kind of net-work round the great vessels. On the fore part of the thigh, and still deep, they enter the lower and deep inguinal glands.

Sometimes these deep lymphatics, instead of being accumulated into larger trunks, divide into many branches, and only unite in the glands of the groin.

Inguinal glands.—The inguinal glands are in number from five to ten; they lie involved in cellular membrane on the outside of the femoral ligament. Some of them are superficial and moveable under the integuments; some involved in the laminæ of the fascia, which descend from the abdominal muscles; some are close on the femoral artery and vein, and under the fascia. Nearer to the pubes may be observed a division

of these glands, which belong to the lymphatics of the penis, perineum, &c.

The greater cluster of glands on the top of the thigh becomes affected from disease of the integuments on the fore part and inside of the thigh and leg; and of that part of the foot where the great saphena vein commences; these inguinal glands swell also from sores of the buttocks, about the anus and private parts. And this is a very common source of error. Many times I have seen a patient under mercury for a supposed bubo of venereal origin, when the real cause was irritation at the verge of the anus.

Lymphatics of the parts of generation in both sexes.—From the penis there run backwards two sets of lymphatics: superficial ones, which take a course to the groin; and deeper ones, which take a course along the arteries of the penis into the pelvis, or under the arch of the pubis. The superficial lymphatics are the cutaneous vessels, and take their origin from the prepuce, and it is these which, either absorbing the venereal matter of chancre, or sympathizing with the venereal action, form sometimes an inflamed line along the penis, and cause the bubo in the groin. But as there are two sets of lymphatics, the chancre may be in a place where the deep-seated vessels are the absorbents, and consequently the constitution may be contaminated without any bubo in the groin; and indeed it has been observed, that a venereal ulcer of the prepuce will, in general, produce bubo, when an ulcer of the glans will not.* When the tract of the matter is through the deep lymphatics which enter the pelvis from below, the gland through which the vessels pass is not inflamed to form a bubo; neither do the lymphatic glands within the ligament of the thigh inflame to the extent of forming a bubo, either from chancre or from bubo in the groin. This, says the celebrated Mr. Cruickshanks, is very fortunate; for if the external iliac glands, like the inguinal glands, should suppurate, they could not be opened by the lancet, they must be left to themselves; they might burst; the pus might fall into the cavity of the abdomen; might produce peritonæal inflammation; and might probably destroy the patient. Now, there appears no reason to dread any such catastrophe. The matter of these glands would form an abscess, which, like other abscesses in the tract of these vessels, would fall down upon the thigh. The fact, however, is curious; that when the inflamed lymphatic enters one set of glands, there will be no bubo; when it takes a course to the other, the gland inflames and suppurates. This I believe may be explained, on considering the position of the inguinal glands, as being immediately under the skin: for experience shows that a part near the surface will inflame and proceed to suppuration much more readily than a part deep-seated, though suffering from the same degree of excitement.

A foreign body, if lying deep, will cause no suppuration or distress; but if it be under the skin and superficial, inflammation and suppuration will be the inevitable and immediate consequences. This may serve to explain why the two glands equally irritated, may be affected differently, and why it is the superficial one that inflames. And here it may be well to notice, that the suppuration which attends these inflamed

* Cruickshanks, p. 138.

glands is not in the body of the gland, but in the surrounding cellular membrane.

In the external parts of a woman (by Mr. Cruickshank's observation) there are also two sets of lymphatics. Those near the clitoris pass up in a direction to the ring; and those from the lower part of the vulva and perineum to the glands of the groin.

LYMPHATICS AND GLANDS WITHIN THE LIGAMENT OF THE THIGH.—The vasa efferentia of the inguinal glands are in number from two to six. The deep lymphatics which accompany the femoral vein and artery, lying under the cellular membrane, pass under the ligament, and soon form a large net-work of vessels accompanying the iliac vessels, and here they are joined by the branches of lymphatics from the superficial glands; sometimes the trunks, accompanying the great vessels of the thigh, pass into a gland immediately within the ligament; sometimes one or two of them only enter into the glands high in the loins; nay, sometimes a large vessel passes on directly to the thoracic duct.

From six to eight or ten glands are seated in the tract of the external iliac vessels, under the name of EXTERNAL ILIAC GLANDS. And upon the inside of the brim of the pelvis, and on the hypogastric vessels, the glands are called the INTERNAL ILIAC GLANDS. In proportion to the frequency of disease in the pelvis, these external iliac glands, being in the tract of the lymphatics of the private parts and rectum, &c., are particularly subject to disease. Those glands also which are called SACRAL GLANDS, as lying on the mesorectum, and in the hollow of the sacrum, have been observed to be often diseased. On the psoas muscle, and on the loins it is impossible to trace the vessels as single trunks; we may observe that one net-work of vessels ascends upon each psoas muscle from the thigh; and it is there joined by the lymphatics of the pelvis. These vessels are in a manner united to those which cover the prominency of the sacrum, and pass under the bifurcation of the aorta. The two GREAT LUMBAR plexuses of the lymphatics continuing their ascent, many of the vessels enter into the lumbar glands; and on the loins they are joined by the absorbents of the testicle. By the union of the lymphatics ascending from the right and left side, with several large trunks of the lacteals from the root of the mesentery, the thoracic duct is formed on the third and fourth vertebræ of the loins.

OF THE LYMPHATICS OF THE ARM.

In the arm, as in the leg and thigh, there are two sets of lymphatics:—the superficial and the deep-seated. The first of these accompany the cutaneous veins, the latter the deep arteries.

As in general there are two great veins on the fore-arm, the basilic and cephalic veins; but particularly as the veins which gather into the basilic trunk, on the inner and lower edge of the fore-arm, are the larger and more numerous class; so it is found that the course of the more numerous class of lymphatics is on the lower and inner side of the fore-arm, and that they accumulate about the basilic vein. These are derived from the palm of the hand, and from the ulnar edge of the hand. This set sometimes passes into glands, seated on the brachial artery, near the inner condyle of the humerus.

The absorbents which accompany the cephalic vein arise from the side of the thumb and fore finger upon the back of the hand; they run on the radial edge of the arm, with the veins which ascend to form the cephalic vein. From the bend of the arm these vessels take a course on the outer edge of the biceps, and then get betwixt the inner edge of the deltoid, and outer edge of the pectoral muscles; they then pass under the clavicle, and descend into the axillary glands. This set of absorbents receives the branches from the outside of the arm in their whole course.

There are absorbents arising from the back of the hand, next the little finger, which following some of the branches of the basiliac vein (a large branch of which is called the ulnaris externa) turn round the ulnar edge of the arm, are inserted into a gland, very commonly found before and a little above the inner condyle of the humerus. From this gland a large lymphatic passes upwards, and attaching itself to the brachial artery, splits and plays around it.

The deep-seated lymphatics of the arm accompany the arteries in the same manner as the venæ comites do; in general two with each artery. They all terminate in the glands of the axilla, and can require no particular description. The lymphatics, from the muscles and integuments on the back of the shoulder, also turn round, and enter into the glands of the axilla.

The GLANDS OF THE ARM are small, and irregularly placed in the course of the humeral artery, from the condyle to the axilla. They are from three to six in number.

The GLANDS OF THE AXILLA are large and numerous; they receive the lymphatics from the arm, breast, and shoulder*; they lie in the deep cavity of the axilla, formed by the tendons of the pectoralis major, and latissimus dorsi muscles. They are imbedded in a loose cellular membrane, which, while it surrounds and supports the vessels of the axilla in the motions of the joint, gives them strength from its elasticity. These glands do not all surround the axillary artery; but a lower cluster is attached to the branches of the subscapular artery, going forward on the side of the chest, and to the thoracic arteries. These are the glands which become indurated from cancer of the breast. The glands of the axilla, when greatly enlarged, close upon the artery and plexus of nerves, so as to preclude the possibility of an operation; they compress the veins and benumb the arm by pressure upon the nerves. When they suppurate, even from causes less formidable, and in scrofulous patients, they sometimes produce a condensation of the cellular membrane in the axillary cavity, which, involving the nerves of the arm, produces weakness and shrinking of the arm.

When a wound or puncture, such as that which the student of anatomy may receive in the dissecting room, has been made on the little or ring finger, the red lines which often appear in consequence of it, have taken the course of the ulnar edge of the fore-arm, and terminate in the inside of the arm, near the condyle; in instances they have been conti-

* "They even receive absorbents from the cavity of the chest, and I have known them swell from the pleurisy, peripneumony, and pulmonary consumption."—Cruickshanks.

nued into the axilla. If venereal matter be absorbed at any part of the hand, near the little or ring finger, or by a sore on those fingers, the gland at the inner condyle of the humerus, or some one in the course of the brachial artery, will most probably inflame and form a bubo, and the surgeon will be aware of this absorption; but if the venereal matter be absorbed on the thumb or fore finger, it is possible that it may not pass into the glands until it comes into the inside of the clavicle. These glands being out of our sight and feeling, the patient may be infected without the surgeon suspecting it.*

LYMPHATICS OF THE HEAD AND NECK.

Of the absorbents of the brain, little is known precisely; but none can deny the probability, that the arteries, veins, and lymphatics bear the same relations in the brain as in the other parts of the system. Lymphatic glands are observed in the course of the internal jugular vein, and even in the foramen caroticum, which are understood to belong to the lymphatics of the brain. The lymphatics of the head are to be observed in the course of the temporal and occipital arteries; the latter class terminate in glands, seated behind the mastoid process of the temporal bone. The lymphatics of the face have been observed to be very numerous, accompanying the facial and temporal arteries. But those from the internal parts of the face and nose accompany the internal maxillary artery, and fall into the glands under the parotid, or in the course of that artery. These glands are liable to disease, from absorption of the matter of abscess in the face, throat, and nose. The lymphatics from the gums and jaws accompany the internal maxillary artery, and emerge under the angle of the jaw; and some of them, joining the external jugular vein, pass through glands near the top of the shoulder. The lymphatic vessels from the tongue and parts about the os hyoides, take also the same course. To know the GLANDS about the FACE and JAWS is of the greatest importance to the surgeon. When brought to a child with a diseased lymphatic gland in the neck, they should not, as I have seen too many do, immediately declare the child scrofulous. They ought to consider the place of the gland and the lymphatic vessels that belong to it, and the part from which that lymphatic comes. By this they will in all probability be directed to some local irritation. There is an inflammation and discharge from behind the ear, and it has produced a swelling of the gland seated below the lobe of the ear. Or the swelling is anterior to the ear, and has proceeded from some irritation in the eyelid or nostril. Or it is a swelling of that gland which is situated upon the facial artery, just under the angle of the jaw, and has come from some excoriation of the lips. Or it is a swelling of some of the glands on the side of the neck, and may have come from some excoriation at the roots of the hair. Or it is more forward and deeper, and then in all probability it has come from some inflammation of the throat.

There are in general several small lymphatic glands, on the side of the face, on the buccinator muscle, immersed in the surface of the parotid gland, and under the zygomatic process. There are also glands to be

* Cruickshanks, p. 182.

carefully noted, which lie under the tip of the parotid gland, where it extends behind the angle of the jaw, and also lying under the base of the jaw-bone, close to the sub-maxillary gland, and on the course of the facial artery.

The GLANDS and ABSORBENTS of the neck are very numerous, and the latter form an intricate and beautiful plexus, several branches of which are to be observed accompanying the external and internal jugular veins. Some of the glands lie immediately under the skin, and in the cellular membrane, on the outer edge of the platisma myoides; many under that muscle, and in the course of the external jugular vein. But there are many seated deep, for the greater number accompany the internal carotid artery, and internal jugular vein, or their branches.

The lymphatics of the THYROID GLAND have been raised by Mr. Cruickshanks, by plunging a lancet at random into the substance of the gland, and blowing into it, or throwing quicksilver into its cellular membrane. The trunks of these lymphatics join the thoracic duct on the left side; and on the right side, the right trunk of the absorbing system, just as it is about to enter into the jugular vein.

OF THE TRUNKS OF THE ABSORBENT SYSTEM.

The larger and proper trunk of the lymphatic system is generally called the THORACIC DUCT, because it was first observed by Pecquet* to be a vessel which conveyed the chyle through the diaphragm, and which took its course through the whole length of the thorax, to discharge its fluids into the veins near the heart. Before his time the lacteals, which were discovered by Asellius†, were supposed to terminate in the liver. The first discoverers of the thoracic duct, described it as beginning from a pyriform bag, to which they gave the name of RECEPTACULUM CHYLI. In dogs, fish, and the turtle, such a cistern or bag may be observed; but in the human body nothing further is to be observed than an irregular dilatation of this vessel, like a varicose distention, where it receives the accession of the lacteals from the root of the mesentery. The origin of this great trunk, called the thoracic duct, is the union of the vessels which ascend by the side of the common iliac arteries and veins, and are derived from the pelvis and lower extremities. Upon the third and fourth vertebræ, and under the aorta, this trunk is frequently joined by a large trunk of the lacteals, and then ascending, it receives the greater number, or the larger trunks of the lacteals. On the vertebræ of the loins, the thoracic duct is by no means regular, either in its course, or size, or shape; often it contracts, and again irregularly dilates, as it seems to emerge from under the aorta. On the uppermost vertebra of the loins, the thoracic duct lies betwixt the right crus of the diaphragm and the aorta. From this point it runs up on the face of the dorsal vertebra, and betwixt the vena azygos and the aorta. On the fourth dorsal vertebra it passes under the aorta to gain the left side of it. Here it is considerably enlarged, from the con-

* In the year 1651.

† In the year 1622.—About the year 1652, the other branches of the system, which take their course to every part of the body, were discovered by Rudbeck, Jolyffe, and Thom. Bartholin.

tracted state which it assumes in the thorax. Sometimes it splits, and again unites on the vertebræ of the back. Still ascending, it continues to incline to the left side, and may be found by the side of the œsophagus.

The thoracic duct now emerges from the thorax, and lies deep in the lower part of the neck, behind the lower thyroid artery, and on the longus colli muscle.

It gets above the level of the subclavian vein of the left side, and here it receives the absorbents of the head and neck (of the left side), and descends again with a curve, and terminates in the angle of the union of the subclavian vein and jugular vein of the left side.

Sometimes there are two thoracic ducts; but this is very rare. Sometimes the duct splits near its termination, and the two branches enter the veins separately; but, in general, when it splits in this manner, it again unites before it terminates in the vein.

There is constantly a trunk in the anterior mediastinum under the sternum, almost as large as the thoracic duct itself, which is sometimes inserted into the termination of the thoracic duct; sometimes into the trunk of the absorbents of the left side, to be immediately described.

THE TRUNK OF THE ABSORBENTS OF THE RIGHT SIDE.

The absorbents, from the right side of the head and neck, and from the right arm, do not run across the neck, to unite with the great trunk of the system; they have an opportunity of dropping their contents into the angle betwixt the right subclavian and the right jugular vein. These vessels then uniting, form a trunk which is little more than an inch, nay sometimes not a quarter of an inch in length, but which has nearly as great a diameter as the proper trunk of the left side.

The trunk of the left side lies upon the subclavian vein, and receives a very considerable number of lymphatic vessels: not only does it receive the lymphatics from the right side of the head, thyroid gland, neck, &c., and the lymphatics of the arm, but it receives also those from the right side of the thorax and diaphragm, from the lungs of this side, and from the parts supplied by the mammary artery. Both in this and in the great trunk there are many valves.

OF THE LACTEALS AND LYMPHATICS OF THE INTESTINAL CANAL.

We shall afterwards have to observe the great length of the intestinal canal, the effect of the imperfect valvular structure, in extending the inner coat to a great length; we have remarked that while every surface of the body secretes, it is at the same time an absorbing surface; and, finally, that while we chiefly contemplate the intestinal canal as imbibing and receiving the nourishment, we must not forget that it is also a secreting surface of the first importance to the economy. But at present we have merely to understand that structure and organization, by which this canal absorbs the nutritious fluid, the chyle, from the food.

In the first place, as to the terms lacteals and lymphatics, we presume that the absorbents throughout the whole length of the canal have the same structure and use; and that the term lacteals has been suggested

merely by the colour of the fluid which is absorbed from the small intestines. At one time these lacteals convey a milky fluid; at another a transparent fluid, like that which the stomach and great intestines in general absorb.

The lacteals, as it is natural to suppose, were the first discovered of any part of the system of absorbents; or, at least, they were first understood to form a part of an absorbing system. For although Eustachius, a Roman anatomist, discovered the thoracic duct in the year 1563, yet he had very imperfect notions of its importance, and the discovery was very little attended to till after the discovery of the lacteals by Asellius in 1622. This anatomist, in opening living animals, to observe the motion of the diaphragm, saw white filaments on the mesentery, which he took at first for nerves; but, on puncturing them, and observing them to discharge their contents and to collapse, he proclaimed his discovery of a new set of vessels—a fourth kind.*

Had Asellius only chanced to observe these vessels, his merit would have been inconsiderable; but he also investigated and announced their peculiar office, viz. of absorbing the chyle from the intestinal canal, and carrying it into the blood.

For some time, however, after the discovery of the vasa lactea, the opinion of Hippocrates and Galen, that the mesenteric veins absorbed the chyle from the intestines, and conveyed it to the liver, still prevailed. Even after the discovery of the lacteals was known and received, a part of the old system was still retained, and it was supposed that those vessels carried the fluids absorbed from the intestines into the liver; and that the chyle was there converted into blood.

About twenty years after the discovery of Asellius, Rudbeck, a Swede, and Bartholin, a Danish anatomist, saw Asellius's vessels in many other parts of the body; discovered the trunk of the system, and showed that the lacteals did not pass to the liver, but that they were branches of a totally distinct system of vessels; they also demonstrated the unity of this system.

We have seen from this sketch that the ancients supposed the veins of the intestines to be absorbents; and even after the discovery of the lacteals, this idea was retained by some of the best modern anatomists, and principally by Haller and Professor Meckel of Berlin. If the veins absorb from the surface of the intestines, their doctrine would imply that they are also absorbents in general throughout the body. Although Bartholin, in his epistle to Harvey, had asserted and given sufficient proof that the mesenteric veins were not absorbents, yet the controversy was left in so undecided a state, as to give occasion to the series of experiments in the school of the Hunters, which seems to have put the question to rest, in as far as it is connected with the lymphatic system.†

We have already mentioned that Asellius was employed in opening the belly of a living dog, when he first discovered the lacteals. He perceived upon the surface of the intestines and mesentery a great many small threads, which, at first sight, he took for nerves, but soon discover-

* The nerves being counted as vessels; there were arteries, veins, nerves, and lymphatics.

† See the VEINS in this volume.

ed his error ; and, to dissipate his doubt, opened one of the largest white cords, when no sooner had the incision been made, than he saw a fluid like milk or cream issue from the vessels. Asellius says he could not contain his joy at the sight of this phenomenon ; and, turning himself to Alexander Tadinus, and the senator Septalius, who were present, he invited them to enjoy the spectacle ; but his pleasure, he adds, was of short duration, for the dog died, and the vessels disappeared. The natural and simple narration of Asellius represents his astonishment, and gives an idea of the sensation, which the anatomist experiences in the instant of making an interesting discovery.

ORIGIN OF THE LACTEALS.—When the young anatomical student ties the mesenteric vessels of an animal recently killed, he finds the lacteals gradually swell ; he finds them turgid, if the animal has had a full meal, and time has been afforded for the chyle to descend into the small intestines ; he finds them empty, or containing only a limpid fluid, if the animal has not had food. When he sees this, he has had sufficient proof that these are the vessels for absorbing the nutritious fluids from the intestines. Again, when coloured fluids thrown into the intestines of a living animal are absorbed, there is sufficient proof of the free communication, and that the extremities of the lacteal are absorbing mouths; but the actual demonstration of the absorbing mouths of the lacteal vessels is very difficult. The difficulty arises from these vessels being in general empty in the dead body, from the impossibility of injecting them from trunk to branch in consequence of their valves ; and, lastly, from their orifices never being patent, except in a state of excitement. The anatomist must therefore watch his opportunity when a man has been suddenly cut off in health, and after a full meal. Then the villi of the inner coat may be seen turgid with chyle, and their structure may be examined. Perhaps the first observations which were made upon this subject by Lieberkuhn, are still the best and the most satisfactory.

The villi are apparently of a cellular structure, for although they are flat or conical, or like filaments when collapsed ; yet when minutely injected, and especially when they are full of chyle, they take a globular form, and are called the AMPULULÆ. Their distension, in consequence of a minute injection of the veins or arteries, is probably owing to their cellular structure, and into which the injection is extravasated. This cellular structure is a provision for their distension and erection by the blood, when excited by the presence of the chyle in the intestines ; this erection gives rigidity to the orifice of the lacteals ; the first absorption being by capillary attraction, while the further propulsion of the fluid in the extreme absorbents is by the contraction of their coats excited by the presence of the fluid. Thus the absorption is not by an inorganized pore, but depending on excitement and action.

Lieberkuhn's observations of the villi are the most accurate and curious. He observes, that having opened and washed a portion of the small intestine, its whole surface will be found covered with little pendulous conical membranes of the fifth part of a line in size, and the basis of which almost touch each other. From the vascular membrane, to which they are attached, he observes there is given off to each villus a branch of a lacteal, an artery, a vein, and a nerve. He found it difficult, by injection to show both the vein and artery, the fluid passed so easily

from the one into the other. He found that the extreme branch of the lacteal was distended into a little vessel within the villus; and surveying the apex with his microscope, he saw one, or, sometimes, several openings. He also observed, with his glasses, the arteries ramifying on the ampululæ, and again collecting into veins; and he supposed that still more minute branches plunged into the centre. But he made a still more minute observation than this. Insulating a piece of intestine betwixt two rings, only leaving a space for the entrance of the ramification of the artery which supplied it, he injected with a column of mercury, and examined its progress at the same time with his microscope. As he raised the tube, he saw the artery going in serpentine turns to the villus, and the injection returning by the veins; at last the injection passed into the ampulla lactea, distended it, and made its exit by the foramina. He prepared the villi in another way: — he inflated the ampullæ, and kept them so until they dried; then he cut them with a razor, and found them cellular. This cellular structure Cruickshanks thinks is the common cellular substance uniting the vessels of the villus. When this gentleman examined the villi of a patient who died suddenly after a meal, he observed some of them to be turgid with chyle, so that nothing of the ramifications of the arteries or veins were to be observed: the whole appeared as one white vessel without any red lines, pores, or orifices; others of the villi contained chyle in a less proportion; and here the ramifications of the veins were numerous, and prevailed by their redness over the whiteness of the villi.

Among some hundred villi he saw a lacteal vessel forming by radiated branches, one branch from each villus.

Mr. Cruickshanks has remarked a deep and a superficial set of lacteals on the intestines; but for this division there seems no necessity. Deep in the coats the lacteals seem to accompany the blood vessels; but when they get more superficial, they take a course longitudinally on the canal, and, after running a little way, they take a sudden turn towards the mesentery.

As the greater frequency of the valvulæ conniventes in the jejunum, greatly increase the extent of the inner surface of that gut, and consequently give a greater extent of origin to the lacteals; and, as here the chyle must be in the greater quantity; so the lacteals of this portion of the gut are larger and more numerous than in any other part of the canal.

The lacteals do not attach themselves to the vessels of the mesentery, but take a more superficial course. Before they enter the mesenteric glands, they have been called lacteals of the first order; when they emerge from the first into the second glands, secondary lacteals, or glands of the second order. The manner of their entering and going out of glands is exactly the same with that of the lymphatics. The lacteals (or perhaps we should now say the absorbents merely) of the great intestines are smaller and less numerous than those of the small intestines; for although the intestines be large, still their inner surface is by no means so extensive: besides, the chyle is absorbed, and the contents of the gut altered before they have descended into the great intestines. Both Winslow and Haller, however, assert that they have seen chyle in the absorbents of the great intestines. We know that the lac-

teals absorb chyle when it is presented to them: while at other times they absorb other fluids. That the absorbents of the great intestines imbibe the fluid contents is evident, from the change produced on the fæces in their passage. Copious and nutritious injections have been given, which did not return in the same liquid form, and which have supported the strength for some time.

Clysters of turpentine give the urine a smell of violets; and the Peruvian bark has cured fever when given by the rectum.

The absorbents of the stomach form three divisions: one set accompanies the coronary artery and vein, and enters the glands on the lesser curvature of the stomach and the omentum minus. Those of the second set accompany the left gastro-epiploic artery, and are joined by the lymphatics of the omentum. The third pass down upon the upper part of the duodenum, following the arteria gastro-epiploica dextra: these descend to pass into the same class of glands, which receive the lymphatics of the liver. The lymphatics of the stomach are joined in their course by the lymphatics of the right side of the omentum.

The lacteals on the mesentery pass from one gland to another, till they form one or two large trunks only. These accompany the trunk of the superior mesenteric artery, and run down on the right side of the aorta, and join the thoracic duct. The absorbents, from the rectum and colon of the left side, pass into their proper glands, or sometimes into the lumbar glands, and join the thoracic duct separately; those from the right side of the colon join or mingle with the lacteals in the root of the mesentery.

OF THE REMAINING ABSORBENTS OF THE SOLID VISCERA.

Where the lymphatics of the lower extremity descend over the brim of the pelvis, they are joined by the absorbents of the bladder, vesiculæ seminales, and other parts in the pelvis:—small glands belonging to this set are attached to the internal iliac vessels. In the female, the lower set of lymphatics, from the womb and vagina, also come by this route to join those of the lower extremity, or run mingling with them. Another set of lymphatics of the womb pass up with the spermatic vessels.

The lymphatics of the TESTICLE are very numerous. They come in distinct sets from the body of the testicle, from the epidydimis, and from the tunica vaginalis: then reaching the cord, form six or ten trunks, and run up direct to the abdominal ring: passing the ring, they turn outward, and then pass over the psoas muscle and into the lumbar glands.

The lymphatics of the KIDNEY are in two sets, superficial and deep-seated; but the former are seldom to be observed. Sometimes disease makes them distinct. The internal lymphatics are demonstrated by blowing into the veins, or tying a ligature and kneading the substance of the kidney with the fingers; when they rise they are seen attached to the emulgent vessels, and go to join the lumbar glands, or terminate in large lymphatics near the aorta.

It is needless to repeat that the absorbents of the spleen are deep and superficial,—for this arrangement is general in the solid viscera. Emerging from the spleen, the lymphatics pass along the splenic ves-

sels, and enter into glands attached to the splenic artery in its whole course. In this course they receive the absorbents from the pancreas, and near the head of the pancreas they are joined with those of the liver, and with them enter into the thoracic duct.

The lymphatics of the liver are the most easily detected, and they may be injected to greater minuteness than any other lymphatics of the body. Although they have many valves, yet they do not seem to close the vessels entirely, nor interrupt the mercury from passing from trunk to branch. The superficial lymphatics, which are so numerous that we may sometimes see the mercury in them covering completely and obscuring a considerable part of the liver, have free communication with the internal set of vessels which are also numerous and large. The principal route of the lymphatics of the upper surface of the liver is by the broad ligament: these, perforating the diaphragm, join the trunk, which we have noticed under the sternum, and in the anterior mediastinum. It would appear, however, that these lymphatics of the broad or suspensory ligament, are by no means constant and uniform in their course: for sometimes they run down towards the lateral ligament, and perforate it there; sometimes they pass down into the thoracic duct while still in the belly: while other lymphatics of great size run off from the convex surface of the liver upon the lateral ligaments, and pierce the diaphragm there. The lymphatics on the lower or concave surface of the liver are more irregular than those of the convex side. They unite with the deep lymphatics coming out of the porta along with the vena portæ, enter into the glands, which are seated on the trunk of that vessel, and join the thoracic duct near the root of the superior mesenteric artery.

The lymphatics of the LUNGS are nearly as numerous as those of the liver; but, indeed, it is more in relation to the facility of injecting and demonstrating the lymphatics, than to their comparative number, that we speak of them in this manner. For example, if the lymphatics of the other viscera could be injected to as great minuteness as those of the liver, we should cease to consider that viscus as more abundantly supplied than other parts. The superficial lymphatics of the lungs form areolæ, and cover the surface almost completely. They take a course to the root of the lungs, where they are joined by the deep-seated vessels, and together pass into the bronchial glands, and here the lymphatics of both sides freely communicate.

The glands of the lungs are constantly found both before and behind the bifurcation of the trachea; often these glands are of a very dark colour, nay, their substance is often found resolved as it were into a sac of inky-like fluid. Upon the arch of the aorta and the root of the great branches are the CARDIAC GLANDS, which receive the lymphatics from the heart. The absorbents from the heart are small, but very numerous, and their larger branches attach themselves to the coronary vessels; they then pass to the cardiac glands and unite with the lymphatics which come from the lungs, and so join the thoracic duct

OF THE BRAIN AND NERVES.

OF THE NERVOUS SYSTEM.

The nervous system embraces the brain, the nerves, and the organs of sense.

The brain is defined to be that soft mass contained within the cranium, from which the nerves are propagated.* The nerves are those white cords visible every where in the parts of the body, having sensation or motion. The organs of the senses are the expanded extremities of certain nerves, within a structure capable of conveying the external impressions to them. The capacity of receiving impressions, the endowment of thought and feeling, and the power of putting the muscular machine into action, are the great attributes of the nervous system.

That sensibility is seated in the nerves, there can be no doubt. Is there any ground for supposing that a different part of the animal compound possesses the same property? It were unphilosophical to suppose so. Where similar qualities or endowments reside, we discover a resemblance in the matter of animal bodies; and it would be foreign to all analogy if two different kinds of matter possessed the same properties. For these reasons I hold, that the susceptibility of receiving impressions, which is the grand distinction of living matter, and the origin of all that is peculiar in the intestinal changes which animals undergo, results from the presence of nervous matter.

If sensibility, in its broadest meaning, results from the presence of nervous matter, then it must be, as anatomy in part proves, and many celebrated men have concluded—the matter of nerve must be extensively distributed, and extend where nervous cords cannot be traced. We have proof of sensibility, that is, of impressions received, and actions thereby excited, where no nerves are visible. And we know that animals, without possessing nervous cords, are susceptible of the impressions and of the re-actions necessary to their existence.

Matter similar to what we see accumulated in masses and in the nerves is expanded every where; and the susceptibility which distinguishes living matter is inherent in it; and through it, therefore, is the most essential endowment of animal bodies bestowed.

* The statement that the nerves are "propagated" from the brain, should be understood as merely expressive of their connexion, or continuity with that organ; not that they are productions or elongations thereof. Researches, to which we shall have occasion hereafter to refer, relative to the development of the nervous system, show that the order of formation is directly inverse to that commonly stated; and these researches are confirmed by observations made in comparative anatomy relative to the successive additions to the nervous system in ascending from the lowest to the highest classes. In acephalous human fœtuses, we find the nerves of the trunk and extremities perfect, although no brain exists; and we have within a few days dissected a fœtus in which both brain and spinal marrow were deficient without any imperfection of the nerves. J. D. G.

Every part having its proportion of nervous matter, and possessing properties through it, what uses are we to attribute to the nervous cords which we see extended through the body, and the nervous masses connected with them?

STRUCTURE OF A NERVE.

The nerves are firm white cords, which are dispersed through the body, and extend to every part which enjoys that sensibility which gives rise to perception, and to every part having a concatenated action with another.

Nerves differ in form; but this appears to be a result arising from their place and relations, rather than connected with any peculiarity of function.

They vary in firmness and density also; but this, like their form, depends upon their places: where they lie protected from injuries, they are soft; when exposed, they are provided with a harder covering.

The matter of a nerve is all that is peculiar in it; for the manner in which that matter is bound up does not differ from the structure of a bone or a muscle. As the phosphate of lime is bound up in cellular membrane, as the muscular fibre is surrounded with cellular membrane, so is the peculiar matter of the nerves bound up and supported by the cellular textures.

Wherever we discover the matter of the nerves, it has certain qualities which distinguish it, whether in masses, as in the brain, or in the organs of the senses, or in the nerves themselves. It is a soft pulpy matter which drops from the probe, being betwixt fluid and solid. When putrid, it acquires a green colour; when dried, it is transparent: corrosive sublimate and muriate of soda harden it; alkalis dissolve it.

The matter of nerve in health, and in the full exercise of its influence, is of an opaque white; by want of use, the matter is either not secreted in due proportion, or it changes its appearance, for the nerve then acquires a degree of transparency.

The coats of a nerve are forms of the cellular texture, and are three in number. They resemble the coats of the brain in structure and in use, and are, as anatomists speak, derived from them, that is to say, they are continuous.*

Some have supposed it possible to inject the nerves. From the na-

* The neurilema is formed of a layer of condensed cellular substance, of argentine lustre, solid and difficult to tear, having its external surface more or less blended with the adjacent cellular tissue; its internal surface is furnished with a vast number of folds or prolongations, which extend into the substance of the nerve. A number of blood-vessels enter this coat, which divide at right angles into two branches, the one direct and the other retrograde, frequently anastomosing. From the internal surface of this tunic serosity is secreted, and almost always oily matter also. Within this external membrane we find a delicate membrane resembling the pia mater, on which the vessels are expanded before they penetrate the nervous substance. When the nervous matter is removed by means of an alkaline solution, the little canals formed by the neurilema may be seen, or the neurilema may be removed by acids, which at the same time harden the nervous matter, so as to render the most delicate fibre visible. Vide Reil de Structura Nervorum, p. 3. 17. F. Meckel, vol. 1. p. 251. Beclard Anat. Gen. p. 587.
J. D. G.

ture of the proper matter of the nerve, this is obviously a thing impossible. In these clumsy experiments they have done no more than to force the mercury into the delicate sheaths of cellular texture in which the tracts of nervous matter are contained and supported.

Inattention to the structure of nerves has led to another mistake, that they have a power of contraction. They are in truth formed with a particular guard against the injury or disturbance of the proper nervous matter by the motions of the frame. Each tube of cellular membrane, or, as it is improperly termed, each fibril of the nerve, is convoluted, running not in a straight line, but zig-zag. I cannot better illustrate this than by a very humble comparison with the thread drawn from a worsted stocking, which has by its form acquired an elasticity which it would not otherwise possess; or with a brass wire which has been wound round a rod, and thereby acquired a spring and elasticity.

I am at a loss to conceive what three celebrated men of our country* aim at, when they would persuade us that nerves are irritable and contractile. For to suppose them capable of contractions or vibrations, is to suppose them sensible to the impression which causes them to contract; and is it not the nature of this sensibility into which they are enquiring? To suppose the nerves to have the property of muscular fibres, does not, I apprehend, tend much to the progress of physiological knowledge. The mind becomes familiarized to an idea which, if it were true, would not aid us in our farther progress of understanding, and, as it is incorrect, leads us astray.

There is an idea prevails that some fluid or spirit is contained in the nerves, for which purpose they are supposed to be tubes. This notion has originally been derived from contemplating the brain as a great secreting organ, and the proof of it is, that it requires five times more blood than any other part; and then they ask, why should it have so much blood if it were not a secreting organ? It is wonderful how general this desire has been of interposing some visible agent to explain effects; yet for my part I am equally at a loss to conceive, how a nervous fluid, more than the vibration of a nerve, should serve to explain the phenomena of a living body.

Fluids, spirits, æther, galvanism, have at different times been supposed to be contained in the nervous tubes, which tubes, be it remembered, were equally matter of conjecture; and many men great in their department of philosophy have been inclined to favour the idea of galvanism being the material of life, because the body of a man after execution can be made to gape and stare, by the application of this penetrating *stimulus!*

How are the oscillations, or tremors, or vibrations of a solid, or the undulations of a fluid, to explain the varieties evinced in the nervous influences? Even if it were to be concluded that galvanism was the means employed in the animal system to stimulate the muscles, it would not follow that the sensibilities of the muscles were also owing to galvanism. Other and greater difficulties would be encountered, on the supposition of galvanism being the agent, than those we have now to contend with.

Some, like Luwenhoeck, have cut the nerves across, and, examining

* *Darwin*, *Home*, and *Abernethy.*

them with microscopes, have thought that they discovered minute hollow vessels; and as it were to prove that we are destined to run ever in a circle, Sir Everard Home, in our Royal Society Transactions, has employed somebody to discover globules in the nerves through the microscope.*

One of the most important considerations regarding the nerves is their supply of blood vessels: their arteries and veins are numerous, and their dependence on the supply of blood immediate. If a limb be deprived of blood, the nerves are deprived of their powers, and sensibility is lost. If a nerve be partially compressed, so as to interrupt the free entrance of blood into it, both the power over the muscles and the reception of sensation through it are interrupted; and when the blood is admitted again, painful tingling accompanies the change. A similar and universal painful tingling accompanies the returning sensibility, and the returning force of circulation after submersion.

How much vain theory has been suggested from the simple experiment of loss of power in consequence of tying a nerve; and yet it was not the compression of the tubes of the nerve, but the obstruction of blood-vessels, which produced the effect.

The brain, the nerve of the eye, the ear, the nerves of sense and of motion, are all affected by the change of circulation; and each organ, according to its natural function, is variously influenced by the same cause—the rushing of blood into it, or the privation of its proper quantity.

SENSIBILITY OF NERVES.

It may appear strange to question the sensibility of nerves; for has not the common testimony of mankind determined that there is nothing so exquisitely sensible as an exposed nerve. But these universal principles of belief are the very circumstances which impede the progress of knowledge on very many occasions. There remains not the slightest doubt in my mind, that there are nerves as perfectly and delicately constituted as those which give sensibility to the eye or ear, which possess no sensibility whatever. That sensibility, therefore, which conveys the impression to the sensorium, and is followed by perception or by pain, is only one out of many functions performed by the nervous system; and I cannot resist stating, that, on the morning I wrote this, I have had my finger deep in the anterior lobes of the brain, when the patient, being at the time acutely sensible, and capable of expressing himself, complained only of the integument.†

When the very seat of perception is found not to be sensible, it leads

* Dellatorre, Prochaska, J. & Ch. Wenzell, Barba, Home, Bauer, and Milne Edwards, have all, at different times, made observations on the globules of the nervous matter. According to the observations of Edwards, the most recent examiner, these globules composing the brain, medulla spinalis, and nerves of the four classes of vertebral animals, are 1 300th of a millimetre in diameter, united together so as to form primitive fibres of a considerable length. Beclard has verified this statement, and considers it of much importance, since all the other animal tissues are composed of similar globules somewhat differently arranged. J. D. G.

† A pistol-ball had passed through the head, and having ascertained that it had penetrated the dura mater, by forcing my finger into the wound, I trepanned on the opposite side of the head, and extracted the ball.

us to consider on what the varieties of sensation depend. We see that sensibility is not an accidental nor a necessary consequence of the structure of a nerve, or the presence of nervous matter, nor even the communication of that nerve with the brain. It is obvious that the sensibility results from the particular part of the brain which is affected by the nerve.

If the eye-ball is pressed, the outward integuments feel pain; but the retina gives no pain, only rings of light or fire appear before the eye. In the operation of couching the cataract, the needle must pierce the retina: the effect, however, is not pain, but to produce, as it were, a spark of fire. And so an impression on the ear, the papillæ of taste, or any organ of sense, does not produce pain; nor does the sensation excited relate to the body which makes the impression, but to the nerve, or rather as I have said, to the part of the brain to which the nerve is related at its root. Ideas of sense are excited according to the part of the brain brought into operation by the touch of the outward nerve.

But the nerve may have no relation to outward impression. It may be a nerve purely for governing the muscular frame; and if it be constituted for conveying the mandate of the will, it will not stand related to an organ of sense in the brain, and no sensibility and no pain will be produced by that nerve. It may be a nerve of exquisite feeling in one sense, that is, it may be a cord which unites two organs in intimate sympathies, so as to cause them to act in unison; and yet being bruised or injured, it will give rise to no perception of any kind, because it does not stand related to a part of the brain whose office it is to produce either the general impression of pain, or heat, or cold, or vision, or hearing: It is not the office of that part of the brain to produce perception at all.

These are very interesting facts, and it is obvious enough, I think, that if physiologists had known or considered the various offices of the nerves, the variety of functions performed by nerves of the same structure, and the various sensibilities of the brain, an accumulated mass of the same material, they would not have thought it a satisfactory improvement to have established vibrations and vibratiuncles, nor to have considered the whole difficulty of nervous influence explained, on the idea of a galvanic fluid being contained in tubes.

OF GANGLIONS.

The ganglions are small reddish tumours seated in the conflux of the nervous filaments. They are laid in a regular succession in the whole length of the body, and in the vertebral animals form a regular series down each side of the spinal marrow; the nerve of communication among them is the great sympathetic nerve.

But besides the spinal ganglions, there are others seated in the head, neck, and cavities of the chest and belly, which are very irregular in their situation and form. Of the latter, the most important from situation and connection is the semilunar ganglion, which with its fellow forms the grand centre of connection to the nerves of the abdominal viscera.

All the ganglions are in the recesses of the body, and placed like parts of importance protected from injury. Around the ganglion there is a

firm, minute tissue of cellular membrane; or we may describe it as a firm dense net-work of fibres so interwoven as to cover the proper substance of the ganglion, at the same time that it enters intimately into its composition; the ganglion has, therefore, a firmness independent of its proper matter, and indeed foreign to the general character of nervous matter. No fat is deposited in the membranes of the ganglions or of the nerves. The colour of the ganglion differs from that of the nerves; it is redder, which is owing to the greater number of blood vessels: when blanched of the blood the ganglions are greyish, and when putrid they are of the green colour of putrid brain.

I conceive that these bodies consist of the same matter with the brain, and that all the difference observable by boiling, macerating, and applying chemical agents, is merely owing to the firmer texture of the membranes which surround them, the intention of which is evidently to protect the proper matter of the ganglion.

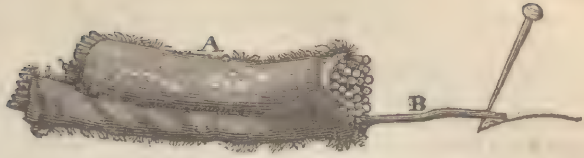
Dr. Monro conceived that there was cineritious matter in the ganglions, and so undoubtedly there is. Scarpa thinks they do not differ from plexuses, being only very minute subdivisions of the nervous filaments. An appearance which countenances this opinion may undoubtedly be given to them by maceration and dissection; but during this process we see that a softer composition peculiar to the ganglion is washed away and lost, and Scarpa admits such a substance betwixt the filaments. Bichat errs on the other side, by affirming that there is nothing fibrous in their appearance, and that they are uniform and homogeneous.

This complicated and beautiful structure of nervous matter, protected by situation and by the support of peculiar membranous texture supplied bountifully with blood vessels, and consisting of white and cineritious coloured nervous matter, has been supposed to be only a means of cutting off the course of sensation to the brain along those nerves which possess such knots or ganglions. But they are undoubtedly organs of importance; and how great their importance may be to the system will be better gathered from the following comparative view of the system of the brain and nerves.

AN EXPOSITION OF THE NATURAL SYSTEM OF THE NERVES ACCORDING TO THE DISCOVERIES OF THE AUTHOR.

The nerves of the human body are, beside the nerves of vision, smell, and hearing, four systems combined into a whole. Nerves entirely different in function extend through the frame; those of sensation; those of voluntary motion; those of respiratory motion; and, lastly, nerves which, from their being deficient in the qualities that distinguish the three others, seem to unite the body into a whole, in the performance of the functions of nutrition, growth, and decay, and whatever is directly necessary to animal existence.

These nerves are sometimes separate; sometimes bound together; but they do not, in any case, interfere with or partake of each other's influence.



The figure represents a nerve, consisting of distinct filaments. A the nerve; B one of the threads dissected out.

If we take up a nerve to examine it, we find that it consists of distinct filaments; but there is nothing in these filaments to distinguish them from each other, or to declare their offices. One filament may be for the purpose of sensation; another for muscular motion; a third for combining the muscles when in the act of respiration. But the subserviency of any of all these filaments to its proper office must be discovered by following it out, and observing its relations, and especially its origin in the brain and spinal marrow. In their substance there is nothing particular. They all seem equally to contain a soft pulpy matter enveloped in cellular membrane, and so surrounded with a tube of this membrane as to present a continuous track of pulpy nervous matter, from the nearest extremity in the brain to the extremity which ends in a muscle or in the skin.

Previous to the observations which I have made, such a nerve as I have described was supposed to have all its threads alike; they were supposed to be branches from the same root, and all capable of exciting a muscle or conveying a sensation.

The key to the system will be found in the simple proposition, that each filament or track of nervous matter has its peculiar endowment, independently of the others which are bound up along with it; and that it continues to have the same endowment throughout its whole length. If we select a filament of a nerve, (for example, one of those in the compound nerve represented above,) and if its office be to convey sensation, that power shall belong to it in all its course wherever it can be traced: and wherever, in the whole course of that filament, whether it be in the foot, leg, thigh, spine, or brain, it may be bruised, or pricked, or injured in any way, sensation and not motion will result; and the perception arising from the impression will be referred to that part of the skin where the remote extremity of the filament is distributed.

As the matter of the nerve is every where the same, and the apparent difference is only in the manner in which the fine cellular membrane forms the envelope, (it being soft where the nerve is protected, hard and cordlike where it is exposed or subject to pressure,) I have been desirous of having some term or terms which might be applicable to the same track of matter through its different stages, whether traced in one direction or the other.

Where certain whitish streaks of nervous matter are discoverable in the substance of the brain, we may still use the term *Tractus*, as being already an anatomical term.

Where, in any part, the line of a nerve is not merely discoverable by

its colour, or the direction of its texture, but when it is raised, and exhibits an external convexity in form of a cord, the term *Column* or *Rod* may be used.

Where they emerge in distinct threads, *Funiculi* has seemed to me a proper term; and where these *funiculi* are projected in combination, I use the word *Fascis*. Although we must keep the term *Nerve*, yet it is, as we may say, an abused term. Let us only distinguish betwixt a simple and a compound nerve. A simple nerve is where the threads or funiculi which form its root arise in a line or sequence from the brain or spinal marrow. A compound nerve is where the threads forming the roots arise in double rows, and each row from a different column or track of nervous matter; for example, the Ninth Nerve is simple; a Spinal Nerve is compound.

A nerve, then, is a cord composed of nervous matter and cellular substance; the nervous matter is in distinct funiculi, and these funiculi are bound together in their course to the point of distribution, and may possess properties quite dissimilar.

If we were successfully to trace a nervous cord, (we shall suppose from a muscle of the fore-arm,) it would be found a simple filament, thread, or funiculus. We should then trace it into a compound nerve; perhaps the ulnar nerve; which we call compound, because there are in it filaments of motion and filaments of sensation bound together. At the root of the axillary nerve we should trace it into the composition of a fascis, where it forms the anterior root of a spinal nerve. Being further traced, it would merge in the anterior column of the spinal marrow; and traced into the base of the brain, it might be followed as a *tractus*, a streak of matter distinguishable from the surrounding substance, until it was seen to disperse and lose itself in the cineritious matter of the cerebrum. In all this extent, however combined or bound up, it constitutes one organ, and ministers to one function the direction of the activity of a muscle of the hand or finger. Even in this respect is its operation perfectly simple, for while it excites the muscle to change its state, which we call its state of contraction or of relaxation, does it also convey to the sensorium a sense of the condition of that muscle?*

And so if we trace other fasciculi, or rather filaments, whether they be for the purpose of sensation or of motion, each retains its office from one extremity to the other; nor is there any communication betwixt them, or any interchange of powers, further than that a minute filament may be found combined with filaments of a different kind, affording a new property to the nerve thus constituted, that is to say, it accompanies it, and gives an additional power to the part where it is ultimately distributed.

THE CAUSE OF THE COMPLEXITY OF NERVES.

It was the chief purpose of my papers in the Philosophical Transactions, to explain the cause of the seeming intricacy of the nerves of the face, neck, and thorax: but independently of the complexity arising

* This, it would be easy to prove, is a very important consideration in studying the organs of the senses.

from the causes afterwards to be explained, there are these :—It will be readily understood that some degree of irregularity in the distribution of nerves, must arise from their being compound nerves ; but the principal cause is the necessity of arranging and combining a great many muscles in their different offices. Wherever we trace nerves of motion, we find, that, before entering the muscles, they interchange branches, and form an intricate mass of nerves, or what is termed a *plexus*. This plexus is intricate in proportion to the number of the muscles to be supplied, and the variety of combinations into which the muscles enter, while the filaments of nerves which go to the skin regularly diverge to their destination. The nerves on the face, and those on the side of the neck, form plexus ; but the grand plexus are near the origins of the nerves of the upper and lower extremity. And from the fin of a fish to the arm of a man the plexus increases in complexity in proportion to the variety or extent of motions to be performed in the extremity.

The explanation of a plexus which I have offered, is founded on these facts ; viz. that by the interchange of filaments, the combination among the muscles is formed : not only are the classes of extensors and flexors constituted in the plexus, but all the varieties of combinations are there formed, and the curious relations established which exist between opposing muscles, or rather between the contraction of one class and the relaxation of the other.

THE SPINAL MARROW.*

In this view of the nerves the internal and radical distinctions are more insisted upon, than that enumeration of their origin and description of their devious course through the body which have hitherto served only to confound the enquirer. We must, therefore, begin the description of the system with that of the spinal marrow. It is by a right arrangement of matters which are familiar, and by attention to a few remarkable and prominent facts, that the ground-work of this system will be best understood.

The spinal marrow is peculiar to the vertebral animals. It will suffice for superficial observers to say, that it must be so, because the spine is necessary to conceal and protect the marrow : but there is much more than this in the established relationship ; the spine formed by vertebræ is necessary to such a constitution of the thorax as shall be capable of the motion of respiration ; and the spinal mar-

* I have represented here, in a general way, the columnar appearance of the spinal marrow at its upper part ; that superior extremity, which, being traced out of the base of the brain, is called *medulla oblongata.*

row is equally necessary to that form and distribution of the nervous system which is required for associating and combining the muscles of respiration. Without the machinery of the spine and ribs, the thorax and abdomen could not rise and fall in respiration; and without the spinal marrow that arrangement of nerves would be wanting, which is necessary to regulate the motions of the trunk in respiration. Thus the spinal marrow, the spine and ribs, and the muscles of respiration, are essential to each other; as constituting the several parts of a grand design subservient to respiration.

Different columns of nervous matter combine to form the spinal marrow. Each lateral portion of the spinal marrow consists of three tracks or columns; one for voluntary motion, one for sensation, and one for the act of respiration. So that the spinal marrow comprehends in all six rods, intimately bound together, but distinct in office; and the capital of this compound column is the *medulla oblongata.*

These six columns of the spinal marrow are discoverable on looking to the fore part of that body; but no doubt these grander columns contain within them subdivisions. Thus, if we lift up the medulla spinalis from the cerebellum, and look to it on the back part, we shall see more numerous cords, the offices of which will one day be discovered.

The medulla oblongata, raised by a thread, so as to expose the posterior surface.

This view of the constitution of the spinal marrow led me to institute experiments, which were followed by the discovery of the distinct functions performed by the several roots of the spinal nerves; but without stating these experiments or their results, we shall proceed with the general view.

The anterior column of each lateral division of the spinal marrow is

for motion; the posterior column is for sensation; and the middle one is for respiration. The two former extend up into the brain, and are dispersed or lost in it; for their functions stand related to the sensorium: but the latter stops short in the medulla oblongata, being in function independent of reason, and capable of its office independent of the brain, or when separated from it.

It is the introduction of the middle column of the three, viz. that for respiration, which constitutes the spinal marrow, as distinct from the long central nerve of the animals without vertebræ, and which is attended with the necessity for that form of the trunk which admits of the respiratory motions.

In animals which do not breathe by a uniform and general motion of their bodies, there is no spinal marrow, but only a long compound and ganglionic nerve, extending through the body for the purpose of sensation and motion. This cord in those creatures does not actuate the animal machine with alternate dilatation and contraction. There may be a motion of some part which admits and expels air from a cavity, or agitates the water, and which motion is subservient to oxygenation of the blood; and there may be a nerve supplied to that apparatus with sensibility and power suited to the function thus to be performed, and resembling our par vagum in office; but there is no regular and corresponding distribution of a respiratory system of nerves to both sides of the body, and no arrangement of bones and muscles, for a general and regular motion of the frame like that which takes place in vertebral animals, and which is necessary to their mode of existence.

OF THE NERVES WHICH ARISE FROM THE SPINAL MARROW.—COMPARISON WITH THE NERVES OF THE ENCEPHALON.

The first conception which I entertained of the true arrangement of the nerves, arose from a comparison of the nerves which take their origin from the brain, with those which arise from the spinal marrow. The perfect regularity of the latter, contrasted with the very great irregularity of the former, naturally led to an enquiry into the cause of this difference. I said, if the endowment of a nerve depend on the relation of its roots to the columns of the spinal marrow and base of the brain, then must the observation of their roots indicate to us their true distinctions and their different uses.

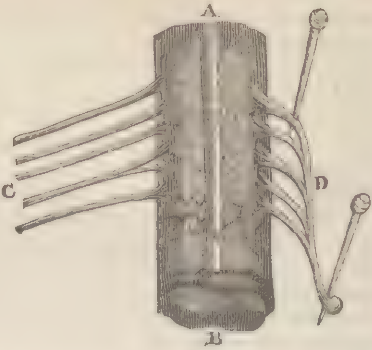
The spinal nerves are perfectly regular in origin and distribution, and are thirty on each side.* Each nerve has two distinct series of roots coming out in packets or fasces, one from the posterior column, and one from the anterior column, of the spinal marrow.

The posterior fascis is formed of funiculi, which come out with remarkable abruptness from the column; and their roots form a very regular row or series along the sides of the spinal marrow. They seem at once to burst out from the confinement of the arachnoid coat. These

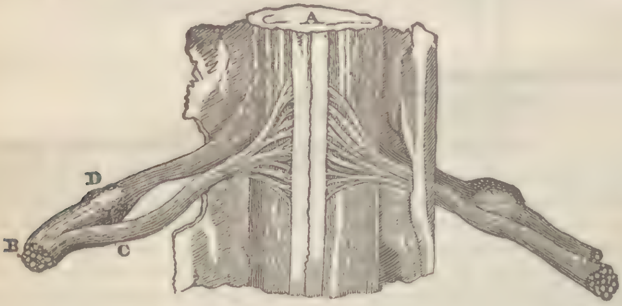
* The tenth nerve of the head, as enumerated by Willis, and called suboccipital from its situation, is in constitution a spinal nerve, *i. e.* it has a double root, a ganglion on its posterior root, and its distribution is similar to the spinal nerves, quite unlike those of the encephalon.

funiculi, converging towards the foramen of the sheath of the spinal marrow, and being collected together, form a ganglion.*

A B the spinal marrow seen laterally; C the posterior roots of a spinal nerve; D the anterior roots of the same nerve pinned out.



This ganglion is not seen within the sheath of the spinal marrow; its seat is in the part where the fascis is surrounded and united to the sheath, and just before this root of the nerve joins the anterior one to constitute a spinal nerve.



A the spinal marrow seen in front; B a spinal nerve; C the anterior root of the spinal nerve; D the ganglion on the posterior root.

The funiculi of the anterior roots of these nerves gather their minute origins with more irregularity than the posterior; and from a wider surface.†

* "I would begin here with again observing an universal oversight of authors, in their description of the ganglion of the spinal nerves. They describe these as formed after the anterior and posterior fasciculi of nervous fibres from the spinal marrow are united, so that every nervous fibre from the spinal marrow is supposed to pass through a ganglion. Instead of this, I have observed that the posterior fasciculus only of the spinal nerve enters into the ganglion, and that authors had been deceived by not slitting open the external coat of these nerves. One half, therefore, of all the nerves of the muscular organs of the trunk of the body, and one half of the nerves of the arms and legs, do not pass through ganglions."—*Munro's Nerv. Syst.* cap. xix.

Scarpa gives a very accurate description of the roots of the spinal nerves in his Annot. Anatom. lib. i. cap. 1. §. xi.

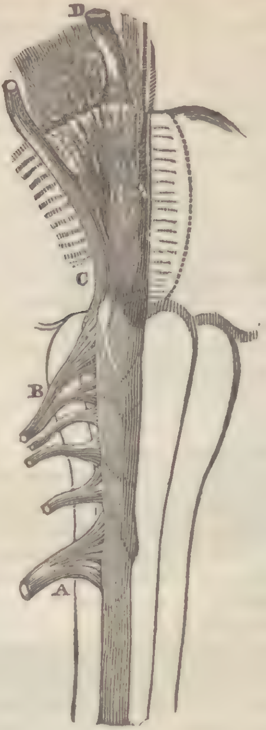
† Prochaska, in describing the difference of the manner by which the two roots of the spinal nerves arise, expresses himself thus:

The thirty nerves thus formed of two distinct fasciculi, are suited to perform all the offices of the trunk and limbs. Is it, then, by that combination of properties which they acquire through their double roots, that they are capable of performing their offices? And is this the cause of their simplicity of arrangement in their course through the body, as contrasted with the nerves of the head? Again, what cerebral nerves, in their distribution to the head and face, correspond in office with the spinal nerves? On the solution of these questions will depend our knowledge of the whole nervous system.

It was necessary to know, in the first place, whether the phenomena exhibited on injuring the separate roots of the spinal nerves corresponded with what was suggested by their anatomy. After delaying long, on account of the unpleasant nature of the operation, I opened the spinal canal of a rabbit, and cut the posterior roots of the nerves of the lower extremity; the creature crawled, but I was deterred from repeating the experiment by the protracted cruelty of the dissection. I reflected, that an experiment would be satisfactory, if done on an animal recently knocked down and insensible; that whilst I experimented on a living animal, there might be a trembling or action exerted in the muscles by touching a sensitive nerve, which motion it would be difficult to distinguish from that produced more immediately through the influence of the motor nerves. I therefore struck a rabbit behind the ear, so as to deprive it of sensibility by the concussion, and then exposed the spinal marrow. On irritating the posterior roots of the nerve, I could perceive no motion consequent, on any part of the muscular frame; but on irritating the anterior roots of the nerve, at each touch of the forceps there was a corresponding motion of the muscles to which the nerve was distributed. These experiments satisfied me that the different roots and different columns from whence those roots arose, were devoted to distinct offices, and that the notions drawn from the anatomy were correct.

The anterior roots of the spinal nerves, and the anterior column of the spinal marrow, being thus shown to have a power over the muscular system, the next step of the enquiry was distinctly indicated. If I pursue the track of the anterior column of the spinal marrow up into the brain, shall I find the nerves which arise from it to be muscular nerves? An anatomist will at once answer, that only muscular nerves arise in this line.

"Anteriora spinalium nervorum principia versus medullam spinalem sunt ramosa; quilibet videlicet funiculus pluribus fere radicibus ex medulla spinali exit, quod vel maxime manifestum est in cervicalibus:" (here he refers to fig. I. plate I., which shows the roots from the anterior surface of the spinal marrow spreading out widely:) "posteriora vero principia funiculos solum clylindricos habent a suo principio ex medulla spinali usque ad eorum perforamina vertebralia exitum." He then describes the peculiarity of there being a ganglion only on the posterior root, and that the anterior root mingles freely with the posterior root, only after it has emerged from the ganglion.



We see here the anterior root of the spinal nerve, arising from the column at A. We trace the column up into the corpus pyramidale, and find there the origin of the ninth nerve B. We see that this nerve has only one series of roots, corresponding with the anterior roots of the spinal nerves, and that these roots come from the *tractus motorius*, and we cannot forget that this nerve is entirely devoted to the muscles of the tongue; that it is the motor of the tongue.

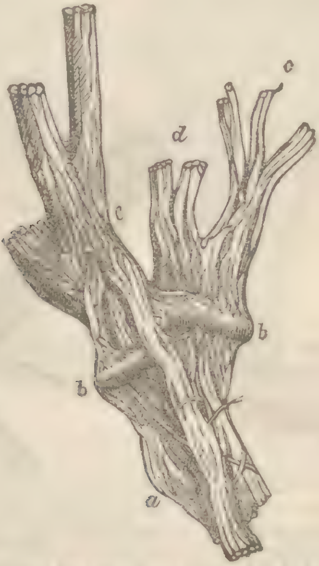
Following up the corpus pyramidale, we find issuing from it the sixth nerve, a muscular nerve of the eye. Still following up the *tractus motorius* through the *pons Varolii*, we come to the roots of the third nerve, the motor nerve of the eye. Thus all the nerves arising in one line from the crus cerebri to the cauda equina are muscular nerves; and no nerves of a different kind arise in all this line.

On finding this confirmation of the opinion, that the anterior column of the spinal marrow, and the anterior roots of the spinal nerves were for motion, the conclusion presented itself that the posterior column and posterior roots were for sensibility. But here a difficulty arose. An opinion has prevailed that ganglia were intended to cut off sensation; while every one of the nerves, which I supposed were the instruments of sensation, had ganglia on their roots.

Some very decided experiment was necessary to overturn this dogma. I selected two nerves of the encephalon; the fifth, which had a ganglion, and the seventh, which had no ganglion. On cutting across the nerve of the fifth pair on the face of an ass, it was found that the sensibility of the parts to which it was distributed was entirely destroyed. On cutting across the nerve of the seventh pair on the side of the face of an ass, the sensibility was not in the slightest degree diminished.

By pursuing the enquiry, it was found that a ganglionic nerve is the sole organ of sensation in the head and face: and thus my opinion was confirmed, that the ganglionic roots of the spinal nerves were the fasces or funiculi for sensation.*

It now became obvious why the third, sixth, and ninth nerves of the encephalon were single nerves in their roots, as contrasted with the spinal nerves: for if the fifth nerve bestowed sensibility universally on the head and face and all the parts contained, there was no necessity, so to speak, for the third, sixth, and ninth, having the posterior or ganglionic root.



a the two roots, *b* the Gasserian ganglion, *c* the ophthalmic division, *d* the superior maxillary division, *e* the inferior maxillary division.

Pursuing the subject and still directed by the anatomy, the next matter of enquiry was to ascertain how far the fifth nerve† of the encephalon corresponded with the spinal nerves. It was discovered that the fifth nerve bestowed sensibility on all the cavities and surfaces of the head and face. It was also observed, that where the sensibility of the inte-

* Scarpa dwells with great minuteness upon the anatomical distinctions between the two roots of the spinal nerves: and then he puts the question, What is the use of the posterior root having a ganglion? Is the posterior root a proper and a peculiar kind of nerve, belonging exclusively to the spinal marrow, whilst the anterior root corresponds with the cerebral nerves? Not being satisfied with this opinion, he suggests whether the ganglion may not be placed upon one of the roots for the purpose of arresting disease and preventing its being carried into the nervous system.—*Annot. Anatom.* lib. i. cap. 3. § 5.

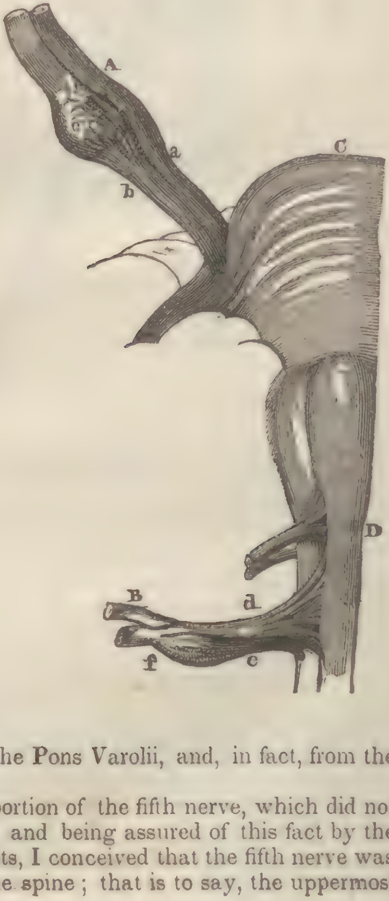
† This woodcut is copied from a drawing of the fifth in Prochaska. A more perfect view of this nerve will be found in the illustration of my last paper in the Philos. Transactions.

guments remained after the division of the fifth nerve, it was only to the extent of surface supplied by the nerves of the spine. Where certain fibrils of the spinal nerve extend upon the integuments of the side of the jaw, these are equivalent in office to those of the fifth nerve. In short, in regard to their property of bestowing sensibility, the fifth and the spinal nerves were identified.

But was the fifth nerve in other essential circumstances similar to the spinal nerves? On recurring to the anatomy, and comparing the fifth nerve of the encephalon with a spinal nerve, the resemblance, both in man and brutes, was very remarkable. In this plan we recognize corresponding parts. In both nerves we see the double roots; the anterior root passing the ganglion, and the posterior root falling into it or forming it. On following back the anterior root, we may perceive that it

We have here a plan of the 5th nerve, and one of the spinal nerves.

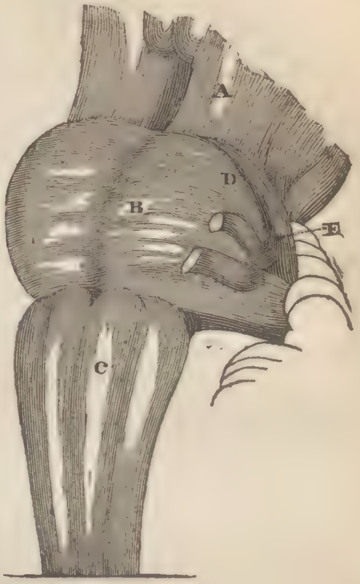
A the 5th nerve; B a spinal nerve; C the Pons Varolii; D the Corpus Pyramidale; a that origin of the 5th which has no ganglion; b the root of the 5th which has a ganglion; c the ganglion; d the anterior origin of the spinal nerve having no ganglion; e the posterior ganglionic root of the same nerve; f the ganglion.



comes out betwixt the *funes* of the Pons Varolii, and, in fact, from the crus of the cerebrum.

Observing that there was a portion of the fifth nerve, which did not enter the ganglion of that nerve, and being assured of this fact by the concurring testimony of anatomists, I conceived that the fifth nerve was in fact the uppermost nerve of the spine; that is to say, the uppermost

or most anterior of those nerves which order the motion, and bestow sensibility, in its extended sense, on the frame of the body.*



A Crus Cerebri; B Pons Varolii; C Medulla Oblongata; D two ropes or funes of the pons, which part to give origin to the anterior root of the 5th nerve; E a fasciculus from the Crus Cerebri, giving origin to the anterior root of the 5th nerve.

To confirm this opinion by experiment, the nerve of the fifth pair was exposed at its root, in an ass, the moment the animal was killed; and on irritating the nerve, the muscles of the jaw acted, and the jaw was closed with a snap. On dividing the root of the nerve in a living animal, the jaw fell relaxed. Thus its functions were no longer matter of

* Prochaska concludes his essay on the Structure of the Nerves with this remarkable passage: "Quis rationem dabit: quare nam nervorum funiculi tam in sua crassitie quam in miris suis plexibus ac concatenationibus per totum suum decursum ludant? Quare radices anteriores nervorum spinalium ganglia spinalia insalutata transeant, et quare non solæ posteriores radices ganglia spinalia transnare cogantur? Et cur radices nervorum spinalium anteriores ramosæ in medullam spinalem inseruntur, aut, si mavis, ex ea medulla oriuntur, dum interim posteriores radices funiculos teretes non ramosos complectuntur? Quare omnium cerebri nervorum solum quintum par post ortum suum, more nervorum spinalium, ganglion semilunare dictum facere debet, sub quo peculiaris funiculorum fasciculus ad tertium quinti paris ramum, maxillarem inferiorem dictum, properat insalutato ganglio semilunari ad similitudinem radicum anteriorum nervorum spinalium? Et plura alia in structura nervorum occurrentia proponi possent, quorum ratio sufficiens reddi nondum potest: attamen utrum unquam reddi poterit, desperandum esse minime videtur, verum liceat interim ea lactari spe, quam tritum proverbium (*dabit dies quod hora negat*) haud raro non vanum fuisse ostendit. —***Prochaska, de Struct. Nerv.*** 1779.

Sœmmerring, when discussing what the probable uses of the ganglions are, likewise associates the fifth pair with the spinal nerves. "Quæ causa est, cur in radice posteriore tantum nervorum spinalium ganglia inveniuntur, minime autem in priore: an priori nervorum spinæ medullæ radici, et minori quinti nervorum paris portioni novo hoc virium augmento non opus est?—*Sœmmerring de Corp. Hum. Fab.* tom. iv.

doubt: it was at once a muscular nerve and a nerve of sensibility. And thus the opinion was confirmed, that the fifth nerve was to the head, what the spinal nerves were to the other parts of the body.

One circumstance I may notice in passing; the origin of the fifth nerve being above or anterior to the termination of the column of the spinal marrow for respiration, it can receive no roots from it. How then are the features to be moved in sympathy with the lungs, and with the respiratory actions of the breast, neck, and throat? We shall find presently that this is effected through the portio dura of the seventh.

I have now only to add, that these opinions and experiments have been followed up to the satisfaction of all Europe. It has been acknowledged that the anterior roots of the spinal nerves bestow the power of muscular motion; and the posterior roots sensibility. When the anterior roots of the nerves of the leg are cut in experiment, the animal loses all power over the leg, although the limb still continues sensible. But if, on the other hand, the posterior roots are cut, the power of motion continues, although the sensibility is destroyed. When the posterior column of the spinal marrow is irritated, the animal evinces sensibility to pain; but no apparent effect is produced when the anterior column is touched.

I shall now proceed, by reference to the plate, to explain the SYMMETRICAL SYSTEM OF NERVES. We see thirty-one nerves similar in origin and constitution, ranging with perfect order, and going forth to the head, body, and limbs in regular succession; and in their essential attributes, common to every class of animals, from the creeping thing up to man.*

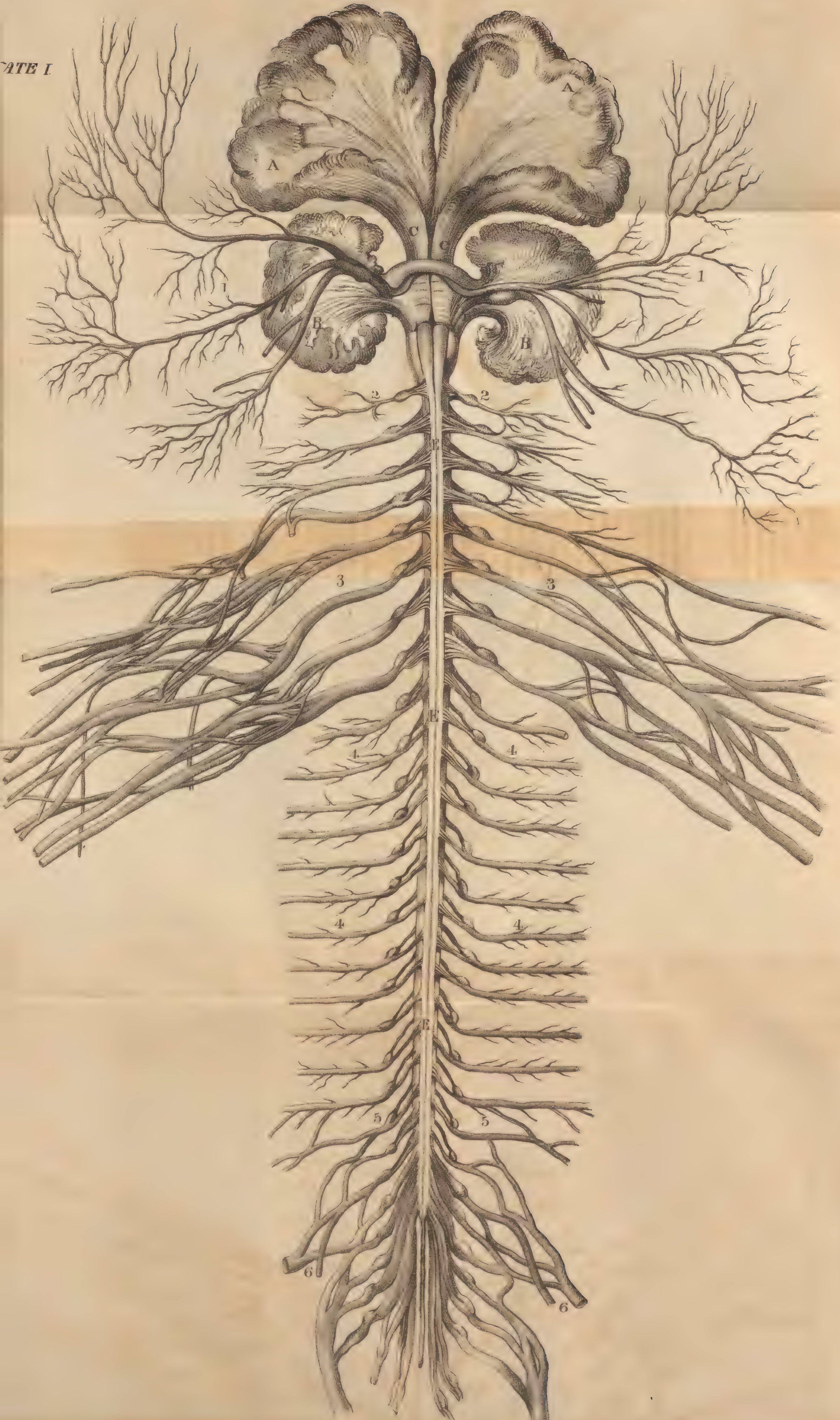
EXPLANATION OF PLANS.

WHEN we contemplate the dissection which we have made of the nerves of the face, neck, and chest, and are lost in the confusion of the VIIth, VIIIth, and IXth, of the branches of the Cervical Nerves, and of the Sympathetic—of the Diaphragmatic, Spinal Accessory, and Inferior External Respiratory Nerves—we shall be prepared to see the advantages of the plans which are annexed. The reader will soon discover that the system, of which the plans may give him some idea, is not only a remarkable improvement in the knowledge of the structure and functions of animal bodies, but is of the greatest use in practical anatomy in facilitating the comprehension of the nerves.

The arrangement is this:—There is an obvious division of the medulla spinalis corresponding to the cerebrum and cerebellum: every regular nerve has two roots, one from the anterior of these columns, the other from the posterior: such are the Vth pair; the Suboccipital; the

* This will be condemned as a term not systematic, but it is strictly correct. It is the necessity of a correspondence in the motions of the body and feet which, if we may so express it, calls for symmetry in the distribution of the nervous system. When a creature has no feet, or substitute for them, there is no symmetrical system of nerves. If we were to consider the necessity of correspondence in the motions of the hands and feet, as well as in the four quarters of brutes, that each foot does not move by itself, but on the contrary, that there is a combination of motion betwixt the limbs in walking, ambling, trotting, galloping, &c., we should see that the muscular system must be united by a longitudinal cord, and uniformity of branches going out laterally.

ATE I.



Pendleton's Lithog

seven Cervical; the twelve Dorsal; the five Lumbar; and the five or six Sacral; viz., thirty-one pairs of perfect, regular, or double nerves in the human body. These are laid down in the first plan. They are common to all animals, from the worm up to the man; and are for the purposes of common sensation and motion, or acts of volition; they run out laterally to the regular divisions of the body, and never take a course longitudinal to the body.*

For the sake of arrangement, the remaining nerves are called IRREGULAR NERVES. These are distinguished by a single fasciculus, or single root; that is, a root from one column. These are *simple* in their origin; *irregular* in their distribution; and deficient in that symmetry which characterizes the first class. They are superadded to the original class, and correspond to the number and complication of the superadded organs. Of these there are—the IIId, IVth and VIth to the eye; the VIIth to the face; the IXth to the tongue; the *Glosso-Pharyngeal* to the pharynx; the *Nervus Vagus* to the larynx, heart, lungs, and stomach; the *Phrenic* to the diaphragm; the *Spinal Accessory* to the muscles of the shoulder; the *External Respiratory* to the outside of the chest.

If we enquire into the seeming confusion in the second class, or *irregular nerves*, we shall perceive that it is owing to the complication of the superadded apparatus of respiration, and the variety of offices which this apparatus has to perform in the higher animals. To explain this the second plan is given. It presents in one view the nerves destined to move the muscles in all the varieties of respiration, speech, and expression.

We may now see how confounding is the numbering of the nerves, according to the system of Willis; and how impossible it is to make a natural arrangement while the nerves are so numbered.

EXPLANATION OF PLATE I.

A A Cerebrum.—B B Cerebellum.—C C Crura Cerebri.—D D Crura Cerebelli.—E E E Spinal marrow.

1 1 Branches of the Vth pair, or Trigeminus, which are seen to arise from the union of the crura cerebri and crura cerebelli: one root coming from the crus cerebri, and another from the crus cerebelli; and on the last a ganglion is seen, like the ganglion of the spinal nerves. The branches of the Vth nerve are universally distributed to the head and face.

2 2 Branches of the *Suboccipital* Nerves which have double origins and ganglions.

3 3 The branches of the four inferior Cervical Nerves and of the first Dorsal, forming the Axillary Plexus: the origins of these nerves are similar to those of the Vth and the Suboccipital.

4 4 4 4 Branches of the Dorsal Nerves, which also arise in the same manner.

5 5 The Lumbar Nerves.

6 6 The Sacral Nerves.

* "Crustaceous animals and insects are the only invertebral animals which have a sort of spinal marrow: it is formed of a double medullary cord, united from space to space by ganglions; we might rather consider it as a great sympathetic nerve." *Cuvier* Leçons d'Anatomie Comparée, tom. 2. p. 100.

There can be no question but that invertebral animals may have nerves for "sensation and motion, or acts of volition," but in such as have neither cerebellum nor medulla spinalis, it is unnecessary and inexact to extend the analogy so positively to them. J. D. G.

OF THE NERVOUS CIRCLE WHICH CONNECTS THE VOLUNTARY MUSCLES WITH THE BRAIN.

I have been slow to make my particular opinions part of this general system, and I have not included my papers in these volumes, until the conclusions in them have received something like a general approbation. I shall, however, shortly notice the subject of a paper which I gave in lately to the Royal Society.

The muscles have two nerves, which fact has not hitherto been noticed, because they are commonly bound up together. But whenever the nerves, as about the head, go in a separate course, we find that there is a sensitive nerve and a motor nerve distributed to the muscular fibre, and we have reason to conclude that those branches of the spinal nerves which go to the muscles consist of a motor and a sensitive filament.

It has been supposed hitherto, that the office of a muscular nerve is only to carry out the mandate of the will, and to excite the muscle to action; but this betrays a very inaccurate knowledge of the action of the muscular system; for before the muscular system can be controlled under the influence of the will, there must be a consciousness or knowledge of the condition of the muscle.

When we admit that the various conditions of the muscle must be estimated or perceived in order to be under the due control of the will, the natural question arises, is that nerve which carries out the mandate of the will capable of conveying, at the same moment, an impression retrograde to the course of that influence which is going from the brain towards the muscle? If we had no facts of anatomy to proceed upon, still reason would declare to us that the same filament of a nerve could not convey a motion, of whatever nature that motion may be, whether vibration, or motion of spirits in opposite directions, at the same moment of time.

I find that to the full operation of the muscular power, two distinct filaments of nerves are necessary, and that a circle is established between the sensorium and the muscle: that one filament or simple nerve carries the influence of the will towards the muscle, which nerve has no power to convey an impression backwards to the brain, and that another nerve connects the muscle with the brain, and acting as a sentient nerve conveys the impression of the condition of the muscle to the mind, but has no operation in a direction outward from the brain towards the muscle, and does not, therefore, excite the muscle, however irritated.

OF THE SYSTEM OF NERVES CALLED RESPIRATORY.

The observation of the frame of man or of brute, and especially the review of it in a state of high activity, or under the influence of passion, will convince us that the motions dependent on respiration extend almost over the whole body, while they more directly affect the trunk, neck, and face. We may perceive, also, that during the involuntary action of respiration the same muscles are in operation as in the voluntary actions. This is evident not only in breathing, but also in coughing, sneezing, crying, laughing, speaking, swallowing, and vomiting; for all these

are states or conditions of the respiratory nerves and muscles. In every effort but that of simple voluntary motion, the respiratory organs become the agents; and even in violent voluntary efforts, or the long continuance of exercise, the instinctive motions chime in with the voluntary motions, and the activity of the frame becomes general.

Under the class of respiratory motions we have to distinguish two kinds: first, the involuntary, or instinctive; secondly, those which accompany an act of volition. We are unconscious of that state of alternation of activity and rest which characterises the instinctive act of breathing in sleep; and this condition of activity of the respiratory organs we know, by experiment, is independent of the brain. But, on the other hand, we see that the act of respiration is sometimes an act of volition, intended to accomplish some other operation, as that of smelling or speaking. I apprehend that it is this compound operation of the organs of breathing which introduces a certain degree of complexity into the system of respiratory nerves. A concurrence of the nerves of distinct systems will be found necessary to actions which at first sight appear to be very simple.

To make this evident, before proceeding further, I shall give an example of the necessity of this combination of different powers. Let us observe, in the act of eating and swallowing, the necessary combination of the three powers of sensation, voluntary muscular activity, and the act of the respiratory muscles.

If we cut the division of the fifth nerve which goes to the lips of an ass, we deprive the lips of sensibility: so when the animal presses the lips to the ground, and against the oats lying there, it does not feel them; and consequently there is no effort made to gather them. If, on the other hand, we cut the seventh nerve where it goes to the lips, the animal feels the oats, but it can make no effort to gather them, the power of muscular motion being cut off by the division of the nerve. Thus we perceive that in feeding, just as in gathering any thing with the hand, the feeling directs the effort; and two properties of the nervous system are necessary to a very simple action.

In drinking, the fluid is sucked in by the breath, and when the mouth is full we swallow. The water is felt; the lips are moulded into the right form by volition, and the muscles of inspiration combine to draw in the fluid. In the act of swallowing, the liquid would descend into the windpipe were there not a combination of the muscles of respiration with the apparatus of deglutition to prevent it; nor could the fluid or the solid morsel pass the diaphragm without a similar coincidence of activity and relaxation betwixt parts animated by different system of nerves.

In speaking, it is still more obvious that the act of respiration must become voluntary, in order to push out the breath, in combination with the contractions of the larynx, and tongue and lips, for producing sound, and more especially articulate language.

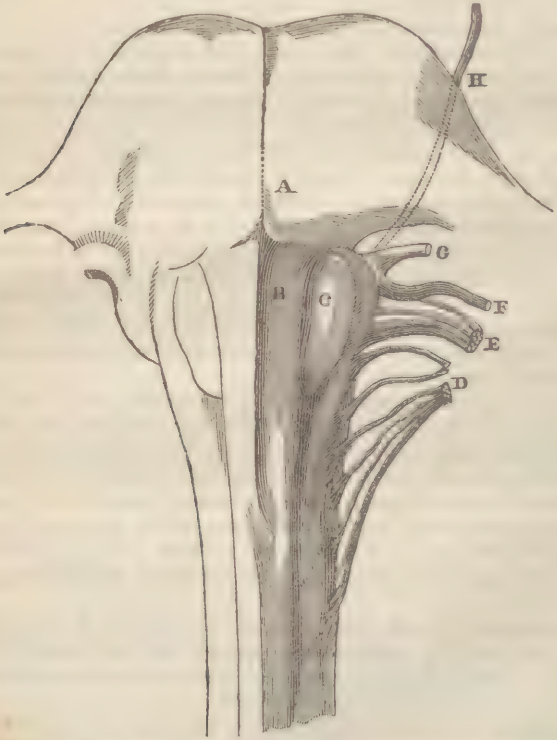
The respiratory system must be exercised under an instinctive and involuntary impulse, as in breathing during sleep, and insensibility. But it must, at certain times, be associated into voluntary actions. By foreseeing this difficulty we shall avoid the danger of pushing the investiga-

tion of the anatomy too far; or of throwing a doubt over important discoveries by attempting too much.

After the investigation of the regular system of nerves of sensation and voluntary motion, the question that had so long occupied me, viz.—what is the explanation of the excessive intricacy of the nerves of the face, jaws, throat, and breast? became of easy solution. These nerves are agents of distinct powers; and they combine the muscles in subserviency to different functions.

As far as regards motion and sensation, the original and symmetrical nerves appeared sufficient to the concatenation of the muscles. By them creatures feel pain, and move and withdraw themselves from injury. But these nerves are not capable of (that is to say, were not designed for) the vital act of respiration, far less from smelling, speaking, singing, laughing, in which several acts the respiratory system is brought into activity.

As animals rise in the scale of beings, new organs are bestowed upon



A the Pons Varolii; B Corpus Pyramidale; C Corpus Olivare; D the Spinal Accessory nerve; E Par Vagum; F Glosso-Pharyngeal nerve; G Portio Dura of the seventh; H Fourth Nerve.

All these are respiratory nerves, arising in a line from the same column.

them. And as new organs and new functions are superadded to the original constitution of the frame, new nerves are given also, and new sensibilities, and new powers of activity.

In the act of respiration we see a succession of regular motions extending to a great part of the animal machinery; we perceive, at one glance, that this is a new species of activity, and that this new energy must be derived from a source different from locomotive powers. Looking to the simultaneous motions of the abdomen, thorax, neck, throat, lips, and nostrils, in breathing, it is obvious, in the first place, that they must be animated by nerves partaking of similar powers; and that these nerves must have a centre somewhere, so that they may be simultaneously and equally excited, and give a uniform impulse to the muscles of respiration.

The reader will now understand the course of my reflections, when I observed that there were certain nerves arising from a distinct column of the spinal marrow, not only different from the spinal nerves, but unlike either of the roots of the spinal nerves; and that they had their roots in a row or regular series. After the course of the enquiry which I have described, it was natural to suppose that these nerves must have a distinct function, and what so probable as that pointed out by their course and distribution? viz.—that they were connected with the offices of respiration. Observing that the Spinal Accessory nerve, the Par Vagum, the Glosso-Pharyngeal nerve, the Portio Dura of the seventh or respiratory nerve of the face, and the Fourth Nerve, arose in a distinct tract and in sequences, I conceived that they offered themselves as fair subjects of experiment; and that by an experiment the question would be determined, viz.—whether or not these five nerves connected the remote parts to which they were distributed in the act of respiration.

The consideration of the course of the Par Vagum (E) gave countenance to this idea, and the comparative anatomy of the nerve confirmed it. On comparing the experiments that had been made from time to time on this nerve, all conspired to show that its use was to combine the proper organs of respiration; while the other nerves (as D F G H) were intended to draw the exterior apparatus of muscles into sympathy with the heart and lungs. Experiments fully confirmed these opinions.

In this course of enquiry it was natural to ask why the Spinal Accessory of authors (D) arose from the spinal marrow in the neck? why it ascended into the head, to join itself with the Par Vagum, instead of following the direct and short route to its destination on the muscles of the neck and shoulder, like the spinal nerves? I divided its branches in the living animal, and by that means cut off certain muscles from partaking in the act of breathing, while they retained their office under the other nerves; that is, they remained under the direction of the will when they had ceased to be influenced by the lungs.

Directed in the next place to the Portio Dura (G), I wished to answer the question, Why does the nerve which supplies the muscles of the face take an origin and a course different from the Fifth Nerve destined to the same parts? By experiment I proved that this was the respiratory nerve of the face: and by inference I concluded, that it had the origin we see, and took its course with the respiratory nerves; because it was necessary to the association of the muscles of the nostrils, cheek, and lips, with the

other muscles used in breathing, speaking, &c. For this reason it was associated with the root of the Eighth Pair instead of the Fifth.

The course of enquiry into the functions of the branches of the Portio Dura which go to the eyelids, led me to make observations on the motions of the eyeball; and finally directed me to the Fourth Nerve (H) to account for the sympathetic motions of the eyeball in combination with the other parts moved in the excited state of respiration.

I may here observe, that on thrusting a pin or the probe into the substance of the medulla oblongata near the root of the Portio Dura (G), and then turning to the other side, we shall find that we have thrust betwixt the roots of the Fourth Nerve.*

This intricate subject is discussed in the last of the series of papers given to the Royal Society, and republished in this volume.

Nothing can better prove the importance of the principles laid down in the beginning of this exposition than the explanation which it offers of the seeming intricacy of the nerves of the orbit and of the whole head and face; and the variety of curious facts which it brings to light. These, as I have said, are detailed in the last of these papers.

It appears, then, that there are four nerves coming out of a track or column of the spinal marrow, from which neither the nerves of sensation, nor of common voluntary motion, take their departure. Experiment further proves, that these nerves excite motions dependent on the act of respiration.

There can be no hesitation or doubt that as far as the neck, throat, face, and eyes depend on, or are related to the actions of respiration, it is through these nerves that they are associated.

I have been always desirous of stating, that the absolute proofs stop here, and that the rest is hypothesis. I imagine that the same column or track which gives origin to the fourth, seventh, glosso-pharyngeal, par vagum, and spinal accessory nerves, is continued downward along the lateral part of the spinal marrow, and that it affords roots to the spinal nerves, constituting them respiratory nerves, as well as nerves of motion and sensation; and that it especially supplies the roots of the diaphragmatic nerve, and the external respiratory nerve.

The spinal nerves are adequate to the gentle and uniform motions of respiration, but not to the associated actions of respiration. Thus, when a creature cries, or a man speaks or sings, the muscular effort is not in the muscles of the thorax only, and directed by the intercostal nerves; but the shoulders are raised and the thorax expanded by the influence of the spinal accessory nerve, and the external respiratory nerves. The larynx is excited by the branches of the par vagum called laryngeal. The cheeks, lips, and nostrils are directed by the Portio Dura and the Fourth Nerves.

It is remarkable that in the investigation of this subject every nerve and twig of nerve is accounted for, and its office explained, with the exception of certain divisions of the sixth nerve of the brain.

* I have indicated the course of the Fourth Nerve by a dotted line

PLATE II.

PLAN of the NERVES of *RESPIRATION.*

EXPLANATION OF PLATE II.

A Cerebrum.—B Cerebellum.—CC Spinal Marrow.—D Tongue.—E Larynx.—F Bronchia.—G Heart.—H Stomach.—I Diaphragm.

1 1 1 Par Vagum, arising by a single set of roots, and passing to the larynx, the lungs, heart, and stomach.

2 2 Superior laryngeal branches of the par vagum.

3 Recurrent or inferior laryngeal of the par vagum.

4 Pulmonic plexus of the par vagum.

5 Cardiac plexus of the par vagum.

6 Gastric plexus or corda ventriculi of the par vagum.

7 Fourth nerve a branch of this system to the trochlearis muscle.

8. Respiratory nerve or portio dura to the muscles of the face, arising by a series of single roots.

9 Branches of the glosso-pharyngeal.

10 Origins of the superior external respiratory or spinal accessory nerve.

11 Branches of the last nerve to the muscles of the shoulder.

12 12 12 Internal respiratory, or the phrenic to the diaphragm. The origins of this nerve may be seen to pass much higher up than they are generally described.

13 Inferior external respiratory to the serratus magnus.

It was said that we understand the use of all the intricate nerves of the body, with the exception of the sixth. The sixth nerve stands connected with another system of nerves altogether; I mean the system hitherto called the sympathetic, or sometimes the ganglionic system of nerves; and of this system we know so little, that it cannot be matter of surprise if we reason ignorantly of the connection of the sixth with it.

On reviewing the whole nerves of the human body, the sensitive, motor, and respiratory systems combined, surely these views come strongly recommended. They present a series of facts unexampled for their number and importance. Such, for instance, as the distinct functions of the nerves of the face; the fact that all sensibility in the head and face depends solely on the fifth nerve; the singular circumstance, that the common sensibility of the whole frame results from a series of ganglionic nerves extending from the head to the sole of the foot; that the act of respiration in the face, nostrils, throat, &c. results from a series of nerves differing from the common nerves: and last of all, it will not be said that I have left the question unresolved with which I set out, viz., the cause of the intricacy of the nerves of the face, neck, and chest. I have shown that the same part, as for example the tongue, has different nerves suited to its different functions; and that the intricacy arises from the interweaving of the branches of different systems. But all this has an easy explanation when we know the properties of the columns from which they proceed.

If there were no facts to give proof of the truth of the view which I have presented, it would surely be enough to recommend it, that a subject which has been hitherto difficult, and intricate, and forbidding, has, by means of it, become interesting, simple, and satisfactory.

INTRODUCTORY VIEW OF THE ANATOMY OF THE BRAIN.

The brain is a mass of soft matter, in part of a white colour, and generally striated; in part of a grey or cineritious colour, which has no fibrous appearance. It has grand divisions and subdivisions: and as

the forms exist before the solid bone incloses the brain ; and as the distinctions of parts are equally observable in animals whose brain is surrounded with fluid, they evidently are not accidental, but are a consequence of internal structure.

On examining the grand divisions of the brain we are forced to admit that there are four brains. For the brain is divided longitudinally by a deep fissure ; and the line of distinction can even be traced where the sides are united in substance. Whatever we observe on one side has a corresponding part on the other ; and an exact resemblance and symmetry is preserved in all the lateral divisions of the brain. And so, if we take the proof of anatomy, we must admit that as the nerves are double, and the organs of sense double, so is the brain double ; and every sensation conveyed to the brain is conveyed to the two lateral parts, and the operations performed must be done in both lateral portions at the same moment.

I speak of the lateral divisions of the brain being distinct brains combined in function, in order the more strongly to mark the distinction betwixt the anterior and posterior grand divisions. Betwixt the lateral parts there is a strict resemblance in form and substance : each principal part is united by transverse tracts of medullary matter ; and there is every provision for their acting with perfect sympathy. On the contrary, the *cerebrum*, the anterior grand division, and the *cerebellum*, the posterior grand division, have slight and indirect connection. In form and division of parts, and arrangement of white and grey matter, there is no resemblance. There is here nothing of that symmetry and correspondence of parts which is so remarkable betwixt the right and left portions.

After observing the great divisions of the brain, the distinctions observable in its substance demand our attention. All the outer surface of the cerebrum and cerebellum is of a grey or cineritious colour. Certain central spots of the cerebrum and cerebellum present the same appearance. The ganglions have also cineritious coloured matter in their composition ; it is found in the spinal marrow and in some of the nerves.

Encompassed by the grey cortical matter, there is a large central portion of white matter, commonly called the medullary substance of the brain. This white substance is striated, and the striæ have a regular order.

FIRST GRAND ORDER OF STRIÆ.—The striæ which first attract attention are those which run across from side to side of the brain : they form the media of communication betwixt the two lateral divisions.

In the cerebrum, we find these striæ converging from the circumference towards the centre, and accumulated in the centre to form the GREAT COMMISSURE. In the cerebellum, the same convergence takes place, and the commissure formed is what is called the PONS VAROLII.

SECOND GRAND ORDER OF STRIÆ.—From the inner surface of the cineritious or cortical matter, striæ of medullary matter descend towards the base of the brain. They converge as they descend ; and the striated structure becoming more distinct and more resembling the nerves, they at last appear extricated from the covering of the cineritous matter, and are what we call the CRURA CEREBRI and CRURA CEREBELLI.

As the crura cerebri are formed by the descending striæ of the cere-

brum, so are the crura cerebelli formed by the descending and converging fibres of the medullary matter of the cerebellum. Certain cineritious masses (insulated from the great cortical mass of the same colour) are observable in the course of these medullary striæ: these masses have hitherto received the names, CORPORA STRIATA, THALAMI NERVORUM OPTICORUM, CORPORA DENTICULATA, CORPUS NIGRUM, &c.

If we continue to trace the crura of the cerebrum, we shall find them still converging and assuming a smaller diameter, and passing under the commissure of the cerebellum (or pons varolii), and joining to the crura cerebelli they are prolonged into the portion called MEDULLA OBLONGATA, and this last portion contracting again is continued into the SPINAL MARROW OF MEDULLA SPINALIS. The *medulla spinalis* has a central division, and also a distinction into anterior and posterior fasciculi, corresponding with the anterior and posterior portions of the brain. Further, we can trace down the crura of the *cerebrum* into the anterior fasciculus of the spinal marrow, and the crura of the *cerebellum* into the posterior fasciculus.

Since the time of Galen down to Cuvier, anatomists have been in the use of describing the medullary matter as descending and passing out to form the medulla oblongata. But there are some authors in the present day who choose to consider the matter as entirely the reverse: the spinal marrow they would describe as the trunk from which the brain expands, and they trace the different divisions of the brain from the several cords or columns of the spinal marrow. What is there in the spinal marrow that it should constitute that root from which the brain is formed? The spinal marrow consists of the nervous centre which orders the actions of respiration, and besides this, it is nothing but the cord of nerve leading to the inferior parts of the body. There is nothing here then, which should in an especial manner be connected with the encephalon or organ of the mind. On the other hand, philosophers say truly that the powers of the mind are developed through the organs of the senses, and if we consider how closely related the operations of the mind are to the impressions received through the nerves of sense, we must be inclined to trace these nerves into the base of the brain, and look for the principal organ of the brain by following the tracts of these nerves into its substance. Comparative anatomy will exhibit the nerves of the senses with the organs of the senses at their further extremities, and the ganglia at their nearer extremities: and when these ganglia run together, they constitute the brain. We ought to enquire what parts of the brain continue to enlarge as the organs of the senses expand, and what parts of the brain bear no correspondence with the change of the organs of the senses. Surely that part of the brain, the developement of which corresponds with the nerves of sense, must be directly connected with them. But if there be portions of the brain which are evolved, and increase, and finally assume the form and size of the cerebrum and cerebellum of the human head; and if these bear no relation at all to the developement of these organs of sense, whilst they bear an intimate correspondence with the developement of the powers of the mind; the natural conclusion is, that they constitute the higher and more important parts of the brain.*

* The relative importance of parts of the brain has nothing to do with the question

OF THE CINERITIOUS MATTER OF THE BRAIN.

Physiologists have been mistaken in supposing it necessary to prove sensibility in those parts of the brain which they are to suppose the seat of the intellectual operations. We are not to expect the same phenomena to result from the cutting or tearing of the brain as from the injury to the nerves. The function of the one is to transmit sensation; the other has a higher operation. The powers of the organs of sense are different; the sensibilities of the parts of the body are very various. If the needle piercing the retina during the operation of couching give no remarkable pain, except in touching the common coats of the eye, ought we to imagine that the part which is the seat of the higher operations of the mind should, when injured, exhibit sensibility, when the nerve of vision does not? So far therefore from thinking the parts of the brain which are insensible, to be parts inferior, (as every part has its use,) I should even from this be led to imagine that they had a higher office. And if there be certain parts of the brain which are insensible, and other parts which being injured shake the animal with convulsions, exhibiting phenomena similar to those of a wounded nerve, it seems to follow that the latter parts, which are endowed with sensibility like the nerves, are similar to them in function and use; while the parts of the brain which possess no such sensibility are different in function and organization from the nerves, and have a distinct and probably higher operation to perform.

If, in examining the structure of the brain, we find a part consisting of white medullary striæ, and fasciculated like a nerve, we should conclude, that as the use of a nerve is to transmit sensation, not to perform any more peculiar function, such tracts of matter are media of communication, connecting the parts of the brain, rather than the brain itself, and the seat of mind. On the other hand, if masses are found in the brain unlike the matter of the nerve, and which yet occupy a place guarded as organs of importance, and holding evidently important relations, we may presume that such parts have uses different from that of merely conveying sensation; we may rather look upon such parts as the seat of the higher powers.

Again, if those parts of the brain which are directly connected with the nerves, and which resemble them in structure, give pain when injured, and occasion convulsion to the animal, as the nerves do when they are injured; and if, on the contrary, such parts as are more remote from the nerves, and of a different structure, produce no such effect when injured; we may conclude, that the office of the latter parts is more allied to the intellectual operations, less to mere sensation.

When we compare the structure of the brain in different animals, we find that in certain lower classes there are no convolutions, the surface of the cineritious matter is uniform. As we ascend in the scale of be-

as to its modes of developement, or as to the best method of investigating the structure. The growth of the brain from the superior part of the spinal marrow is incontestibly proved by the observations made in comparative anatomy, as well as by the recent researches of Tiedemann concerning the growth of the fœtal brain. In another place a sketch of these proofs of the developement of this important organ will be given. J. D. G.

ings, we find the extent of the cineritious matter increased. To admit of this, it is convoluted; the depth of the sulci are the consequence of the extension of the cineritious mass; and in man above all other animals are the convolutions numerous and the sulci deep, and, consequently, the cineritious mass great, and its extension of surface far beyond that of all other creatures.

Another circumstance which points out the importance of the cineritious matter of the brain is, that every portion has a fibre of medullary matter which runs across and forms a commissure with the corresponding portion of the opposite side.

Unless the cineritious masses were important organs, why should there be commissures or nerves forming a distinct system arising and terminating in nothing? But if we take them as commissures, *i. e.* bonds of union betwixt the corresponding sides of the great organ of the mind, we at once perceive how careful nature is to unite the two lateral organs together, and out of two organs to make ONE MORE PERFECT.

If we grant that this cineritious matter of the brain is an organ or organs of importance, then we may also acknowledge that the portions or masses of cineritious coloured matter which we discover in remote parts of the nervous system minister to some similar important office. The ganglia have all cineritious matter in their composition; and there are portions of cineritious matter found in the crura or processes of the brain, and in the spinal marrow.

I have found at different times all the internal parts of the brain diseased without loss of sense; but I have never seen disease general on the surfaces of the hemispheres without derangement or oppression of the mind during the patient's life. In the case of derangement of mind, falling into lethargy and stupidity, I have constantly found the surface of the hemispheres dry and preternaturally firm, the membrane separating from it with unusual facility.

From these considerations I must conclude, that the cineritious matter of the brain is the seat of intellect, and the medullary the subservient parts.*

At first it is difficult to comprehend, how the part to which every sensation is referred, and by means of which we become acquainted with the various sensations, can itself be insensible; but the consideration of the wide difference of function betwixt a part destined to receive impressions, and a part which is the seat of intellect, reconciles us to the phenomenon. It would be rather strange to find that there was no distinction exhibited in experiments on parts evidently so different in function as the organs of the senses, the nerves, and the brain. Whether there be a difference in the matter of the nervous system, or a distinction in organization, is of little importance to our enquiries, when it is proved that their essential properties are different, though their union and cooperation be necessary to the completion of their function, viz. the developement of the faculties by impulse from external matter.

* We cannot believe that this conclusion of our author is founded upon sufficiently extensive observation, because a great number of instances are on record in which the intellectual operations were apparently uninjured, notwithstanding the cineritious substance of both hemispheres was very considerably diseased, and even removed by ulceration. See Haller's Opera Minora, &c. J. D. G.

OF THE CEREBELLUM.

Although the cerebellum be composed of the same nervous matter with the cerebrum, and although there be here also the distinction of cineritious and medullary matter, yet in form and in internal arrangement it is quite unlike the cerebrum.

Betwixt the lateral portions of the cerebrum there is a strict resemblance, and an intimate connection is preserved by the commissures; that is to say, every part is united by transverse tracts of medullary matter, and there is every provision for their acting with perfect sympathy.

On the contrary, the cerebrum, which is the anterior grand division of the brain, and the cerebellum the posterior grand division, have slight and indirect connection. In form and division of parts, and in the arrangement of white and grey matter, there is no resemblance betwixt them; therefore there is nothing of that symmetry which is so remarkable in comparing the sides of the brain. There cannot therefore be a correspondence in their functions.*

We have already explained that the cerebrum has connection with the anterior columns of the spinal marrow, and the cerebellum with the posterior columns. And no one has given reason to doubt the correctness of the statement that I have made, that the anterior column is for motion, and the posterior for sensibility. If we were to indulge in opinions which we could not bring to the test of experiment, we should say that the cerebrum had power over the motions of the body, and the cerebellum over its sensibility. This only I know for certain, that the destruction of the hemisphere of the cerebrum destroys the motion of the corresponding part of the body; but I have seen no decided proof that the injury of the cerebellum destroys the sensibility of the corresponding part of the body. I have no doubt that we shall find out the functions of these different parts of the encephalon, although the experiments made hitherto have been rude and unsatisfactory.

OF THE MEDULLA OBLONGATA.

Although the medulla oblongata is in our systematic works always termed one of the three great divisions of the brain, it is in truth no more than the medullary matter which we trace from the cerebrum and cerebellum into the spinal marrow. If we speak of the spinal marrow as a column of nervous matter, the medulla oblongata resembles the ornamented capital of that column.

Looking to future improvement, the great desideratum in the investigation of the brain is, to ascertain which are the essential and fundamen-

* The cerebellum, though not so strikingly symmetrical as the cerebrum, is nevertheless actually as regular. The right and left portions of the cerebellum are perfectly correspondent, and the one portion is fully adequate to perform the functions of the other, in case of any accidental impairment. By the expressions of the author, nothing more is meant than that the cerebrum and cerebellum are very different in construction and office. The *symmetry*, or correspondence of parts, is perfect in both organs. J. D. G.

tal parts, and which are the superadded parts; and, in the next place, to determine what is the difference produced on the arrangement of these parts, in consequence of the animal possessing a spinal marrow.

The formation of the spinal marrow requires an entire change in the arrangement of the nervous system, both brain and nerves. When there is a spinal marrow there is a cerebellum, but none without it. From the cerebrum and cerebellum go down processes, to form the spinal marrow. When a spinal marrow is given, there is a regular series of nerves, arising from it by double origins. To what then is owing this remarkable change in the arrangement of the nerves? To the possession of a regular apparatus for respiration; the respiration by ribs, abdominal muscles, and diaphragm, requires that distribution of nerves which is bestowed through the spinal marrow, and thus influences the arrangement of the whole nervous system.

In the lower animals, in insects, worms, and snails, there is a nervous thread extending from one ganglion to another, in all their length. There is nothing which, by its magnitude, would indicate a *brain;* for the ganglion in the head is smaller than the ganglions in the body. Linnæus said, insects have no brain. But wherever there is concatenated motion, there is a brain; as in the nervous system of the caterpillar, the worm, or the slug. If we cut off the anterior ganglion, it will be found that the direction of motion is lost. If a worm be divided, it will have abundant motion in the posterior division; but the anterior division is possessed of the power of combining, which enables it to remove itself from the injury: the anterior portion will move away, while the posterior twists itself in the same spot. The nervous system of insects is full of interest: as we see an exact adaptation of the nerves to the organs and muscles, and a dependence of the brain upon the arrangement of the nerves. It is interesting to see, in the change from the larva to the winged state, how the brain, ganglions, and nerves accompany these changes of the organs of motion.

Notwithstanding that the brain in the lower creatures is distinguished as the source of volition, in them it is not of the same value to life as in the higher animals. In man it is not only beyond calculation great in its appropriate energies, but, as a vital part, it is of the first class, and second only to the stomach.

OF THE MEMBRANES OF THE BRAIN,

AND

OF THE SUBSTANCE AND TEXTURE OF THE BRAIN ITSELF.

OF THE DURA MATER.

Many authors, while they describe the cranium as containing the brain, conceive that it also gives it shape. But the brain is formed before the bones which invest it. The first thing that we observe in the embryo is the disproportionate size of the brain to the diminutive body.

The ossification of the bones of the skull is a gradual process. The brain, already formed, is invested with the strong membranes; and betwixt the laminæ of the outer membrane the points of ossification commence, and are not completed until the ninth year. The bony matter, which is deposited betwixt the layers of this membrane, retains a firm connection and interchange of vessels with the now apparently distinct membranes on its inner and outer surfaces. The outer layer, which is so strong in children newly born, becomes the delicate pericranium, whilst the inner layer is the dura mater. Thus we find that the bones of the head are moulded to the brain, and the peculiar shapes of the bones of the head are determined by the original peculiarity in the shape of the brain.*

This view corrects an error into which many have fallen, that the dura mater and the vessels ramifying upon it impress their form upon the solid bones, and wear channels upon their surface by their incessant pulsation. The membranes and vessels precede the formation of the bone, and the osseous matter is deposited so as to be moulded round the vessels.†

Thus the dura mater may be considered as the internal pericranium.‡

The dura mater § is a firm opaque membrane of considerable thickness.—When the skull-cap is torn off, and it is cleaned from the blood which escapes from the ruptured vessels, it is seen marbled with azure and rosy colours. Its outer surface is rough, from the adhesions to the bone being torn up: but on the surface lying in contact with the brain, it is smooth, shining, and of a pearl colour.

Although the dura mater is really the strongest membrane of the body, it is yet divisible into laminæ; these are firmly connected by the intertexture of strong fibres. Most anatomists describe it as composed of two laminæ.‖ Some, however, describe three laminæ: the outer lamina, or squamosa; the middle, or filamentosa; and the internal (being smooth and uniform), the lamina membranosa.¶ But to separate the dura mater into such laminæ, it will, I believe, be necessary to dry it and tear it into shreds. No doubt it may be possible thus to tear it, as some have done, into four, six, seven, or even eight laminæ or squamæ. It is to be regretted that anatomists should have been proud of such dissections.

* Certainly the skull is adapted to the form of the brain. But there is a deeper question which our craniologists have forgotten. Is the brain constituted in shape with a reference to the future form of the head? No doubt it is.

† Albini Acad. Anat. "Quomodo cranium crescendo accommodat se eis quæ continet."

Fischer, Dissertatio de modo quo ossa se vicinis accommodant partibus.

‡ Some regard only its external lamina as the internal pericranium. Haller, t. iv. p. 92. Fallopius first viewed the dura mater in this light, and he is followed by the best anatomists.

§ The membranes of the brain have the name of *mater*, because they defend the brain, and protect its tender substance; or, according to some anatomists of the Arabian school, because the other membranes of the body are produced from them. Before Galen, the term Meninx was common to all the membranes of the body, afterwards it was appropriated to those of the brain.

‖ Sœmmerring Corp. Hum. Fabrica, t. iv. p. 26. Haller, t. iv.

¶ Malacarne, p. 22. It is described as partly tendinous, partly ligamentous; that is to say, of a nature resembling these, yet not altogether the same. Vicq d'Azyr found it separated by purulent matter into two laminæ, the fibres of which had a different direction. Acad. des Sciences, An. 1781, p. 497.—Bartholin Sp. Histor. Anatomiæ

The dura mater is insensible, as we prove by the operation of trepan; it has, in the way of experiment, been pricked and injured by every possible contrivance, by mechanical and by chemical stimulants; yet the animals, the subjects of such cruel experiments, have given no sign of pain.* Before the fact of the insensibility of the dura mater was thus established, physicians regarded this membrane as the seat and origin of many diseases.†

Formerly the natural connection of the skull and dura mater was so resolutely denied, so hotly contested among the various parties in anatomy and surgery, that we might, by reading their disputes, almost doubt one of the plainest and most obvious facts, were not the closeness of this connection sufficiently proved by the manner of the original formation of the cranium, and by the bleeding surface of the dura mater when the bone is raised; or, if further proof be required, we may macerate these bones and their membranes in acids, when the laminæ of the dura mater will be seen intimately connected with the bone, while the pericranium and outer laminæ of the dura mater are seen to be continued into each other‡, by the intermediate cellular texture in which the earth of the bones was lodged.§

The dura mater adheres more firmly to the bone in young subjects, because the bone is yet imperfect, and its surface spongy and rough; and for the same reason it is more firmly attached to the skull in the chronic hydrocephalus, because the ossification is imperfect. It frequently adheres so firmly to the skull-cap, as to leave its outer lamina adhering to the skull when it is raised.

GLANDS OF THE DURA MATER.

Upon the external surface of the dura mater there are little holes, from which emerge fleshy-coloured papillæ, and which, upon examining the skull-cap, will be found to have corresponding foveæ. These are the glandulæ Pacchioni.‖ They are in number from ten to fifteen¶ on each side, and are seen chiefly lateral to the course of the longitudinal sinus. These bodies were supposed by Pacchioni to be glands. When pressed, they gave out a fluid**; but in this they do not differ from the loose common cellular membrane. As they are chiefly seen along the line of the great sinus, and are not scattered over the whole dura mater, their supposed use of moistening the surface of the membrane†† is quite improbable;

* Zinn. Exper. circa corpus callosum, cerebellum, duram meningem.—Mém. par Haller sur les Parties sensibles et irritables.—Blegny, Journal de Méd. An. I. p. 16.

† See Hoffman. Med. Ration. part 2. sec. ii. c. 1. § 2. and Boneti Sepulch. Anat. lib. i. sec. i.

‡ Vicq. d'Azyr, Mém. de l'Acad. Roy. 1781, p. 497, and Malacarne (Aderenze della D. M. alle pareti interne del cranio), p. 24.

§ Taking a portion of the dura mater betwixt the finger and thumb, we can move the two laminæ upon each other, owing to a slight degree of laxity in the connecting cellular substance. This cellular texture is demonstrated by Malacarne, by forcibly injecting quicksilver betwixt the layers of the membrane.

‖ See M. Littre Acad. Roy. des Sciences, 1701. Hist. p. 32. art. 19.

¶ Haller, El. Phys. p. 106. Mém. par M. Vicq d'Azyr, Mém. de l'Acad. Roy. 1781, p. 497.

** Malacarne.

†† Viz. the opinion of Fantonius.

and, indeed, this is a part of that unfounded hypothesis which supposed an interstice between the dura mater and skull, and ascribed independent motion to this membrane. The surfaces of the dura and pia mater, where they are in contact, being of the nature of the secreting surfaces of the investing membranes of the other viscera, require no such further aid in moistening them or preventing their adhesion. Many glands are described by authors in the substance and upon both surfaces of the membrane. Of the bodies which adhere to the surface of the pia mater, and of those also which are to be seen in the sinuses, we shall speak afterwards, when considering the veins which enter the longitudinal sinus.

ARTERIES OF THE DURA MATER.

This membrane must necessarily be supplied with vessels for its own nourishment, for that of the contiguous bone, and for the perpetual exudation of the fluid which moistens or bedews its internal surface. We may divide the arteries of the dura mater into anterior, middle, and posterior. The first proceeding from the ophthalmic and ethmoidal branches of the internal carotid; the second from the internal maxillary and superior pharyngeal; the posterior from the occipital and vertebral arteries and posterior auris.*

The principal artery of the dura mater, named, by way of distinction, the great artery of the dura mater, is derived from the internal maxillary artery, a branch of the external carotid. It is called the spinalis, or spheno-spinalis, from its passing into the head through the spinous hole of the sphenoid bone; or meningea media, from its relative situation, as it rises in the great middle fossa of the skull. This artery, though it sometimes enters the skull in two branches†, usually enters in one considerable branch, and divides soon after it reaches the dura mater into three or four branches, of which the anterior is the largest; and these spread their ramification beautifully upon the dura mater, over all that part which is opposite to the anterior, middle, and posterior lobes of the brain. Its larger trunks run upon the internal surface of the parietal bone, and are sometimes, for a considerable space, buried in its substance. The extreme branches of this artery extend so as to inosculate with the anterior and posterior arteries of the dura mater, and through the bones (chiefly the parietal and temporal bones) they inosculate with the temporal and occipital arteries.‡

The meningeal artery has been known to become aneurismal and distended at intervals; it has formed an aneurism, destroying the bones, and causing epilepsy.§

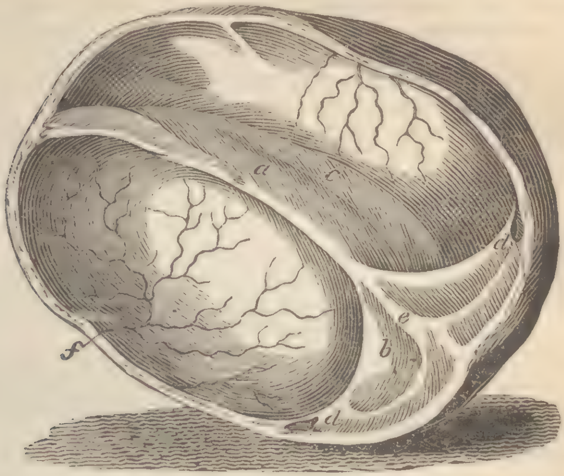
* Sœmmerring, C. H. Fabric. A. Murray, Descrip. Arteriarum, in tab. redact.

† Sœmmerring de Corp. Hum. Fab. tom. v. p. 142. This is not the sole artery sent to the dura mater from the internal maxillary: a twig also rises from that branch which goes to the pterygoid muscles and parts about the Eustachian tube—it enters the skull, and is distributed to the fifth pair of nerves, and to the dura mater and cavernous sinus; another enters with the inferior maxillary nerve by the foramen ovale, and rises upon the dura mater.

‡ Malacarne.—Sœmmerring, tom. v. p. 142.

§ Malacarne, p. 1. sec. 105.

THE SKULL-CAP, WITH THE DURA MATER ADHERING.



(*a*) Falx—(*b*) Tentorium—(*c*) Longitudinal Sinus—(*dd*) Great lateral sinuses (*e*) Fourth sinus—(*f*) Artery of the dura mater.

OF THE SEPTA WHICH INTERSECT THE BRAIN.

Those septa, or, as they are called, processes of the dura mater, being extended across from the internal surface of the cranium, support the brain in the sudden motions of the body, and prevent the gravitation of its parts; but I believe they are chiefly useful in retaining the sinuses in their triangular form.

These partitions are formed by the reflection of the internal lamina of the dura mater.

The falx is the largest of the partitions; it is attached to the cranium in the line of the sagittal suture, and reaching from the crista galli of the ethmoid bone to the middle of the tentorium, or to the crucial ridge of the occipital bone, it passes deep into the middle of the cerebrum, and divides it into its two hemispheres. It is in shape like a scythe, for anteriorly it does not pass so deep into the substance of the brain; but it gradually becomes broader, or descends deeper betwixt the hemispheres, as we follow it backwards, which, with the curve it necessarily takes from the shape of the cranium, has obtained it the name of falx: it is also called septum sagittale, verticale, or mediastinum cerebri.*

The TENTORIUM separates the cerebrum and cerebellum. It stretches horizontally over the cerebellum, and sustains the posterior lobes of the cerebrum. It is formed by the inner lamina of the dura mater, reflected off from the os occipitis along the whole length of the grooves of the

* The falx has not been found in some subjects. Garengeo Splanchnologie. Mr. Carlisle, Medical Transactions, 1793.

lateral sinuses, and the edge or angle of the temporal bones. This septum, thus running round the cavity of the cranium, divides it into two departments; the upper one for the lodgment of the cerebrum, and the lower for the cerebellum. But to allow the union of these two great divisions of the encephalon, a circular opening is left upon the anterior part of the tentorium, which is called the notch of the tentorium.

There is a little process of the dura mater, which may be called the FALX of the CEREBELLUM. It runs down upon the internal spine of the occipital bone from the tentorium, gradually contracting until it terminates on the margin of the great occipital foramen. It serves as a kind of ligament strengthening the tentorium, while it divides the cerebellum. It enters, however, but a little way betwixt the lobes.

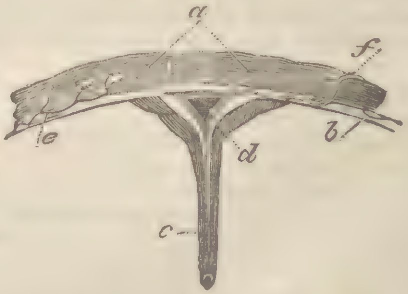
The falx and tentorium being connected and continued into each other at their broadest part, they mutually support each other, and are quite tense. This tenseness depends on their mutual support; for when one of them is cut, the other falls loose.*

The lateral extremities of the tentorium are continued forward into acute lines, formed by the duplicature of the dura mater coming off from the edges of the pars petrosa of the temporal bones, and take firm hold on the posterior clynoid processes. From these two points a fold of the membrane stretches forward on each side to the anterior clynoid process, forming thus a hollow or cell for the lodgment of the pituitary gland. Another fold or duplicate of the dura mater runs onwards a little way from the edge of the little wing of Ingrasias. These are the SPHENOIDAL FOLDS.

Where the internal lamina of the dura mater forsakes the external to form the falx and tentorium, it leaves a channel or triangular canal; the basis of which triangle is the lamina of the membrane investing the cranium, while the tension of the partitions carries the apex out into an acute point. This forms a channel for receiving all the blood of the veins, and this tension and triangular shape gives a degree of incompressibility to the canals. These are the sinuses which receive the veins of the encephalon, and guard them from compression:—

SECTION OF THE LONGITUDINAL SINUS.

(*a*) The skull.
(*b*) The dura mater.
(*e*) The extremities of the artery of the dura mater passing into the bone.
(*c*) The falx.
(*d*) The sinus.
(*f*) A branch of the temporal artery passing into the dura mater.



Upon the surfaces of the dura mater there are many lacerti, or slips

* Monro.

of fibres, which are interwoven with the membrane, so as to strengthen it. These fibres are peculiarly strong in the angles, where the duplicatures pass inwards, giving firmness to the sinuses, while they allow the veins to insinuate their trunks betwixt them; these fasciculi, or slips of fibres, on the sides of the sinuses, are the cordæ Willisianæ. They were considered by Baglivi and Pacchioni* as the tendons of the muscles of the dura mater, Pacchioni conceiving that this membrane was muscular. Vicq d'Azyr observes, that in inflammation of the dura mater he has seen it red, and of a fleshy appearance; and that such a circumstance might have deceived Pacchioni, and made him believe that there were muscular bellies.†

These physicians conceived that the contraction of the falx and dura mater raised the tentorium; they even conceived that the action of the heart depended upon this motion of the dura mater.‡ They were deceived by the pulsation in the arteries of the brain, communicated to the dura mater, after the operation of trepan, or in their experiments on living animals.§

The motion communicated to the dura mater those Italian anatomists conceived to depend on the rising of the tentorium. This motion, which is occasioned by the beating of the arteries of the brain, had been long before observed‖. some conceived it to be a motion of the brain itself, others believed it to depend on the sinuses.¶

The motion caused by respiration was likewise observed.** M. de Lamure's conclusion was, that the motion of the brain was caused by the reflux of the blood towards it from the vena cava in expiration.†† He undertook to demonstrate this; and he conceived his proof to be good, when, by pressing the ribs of a subject, he saw the refluent blood swelling the jugular and abdominal cava. Haller observed the jugular veins swell, and become turgid, during expiration; and he concluded, that the motion of the brain was occasioned by the refluent blood distending the sinuses of the brain. But he did not believe, as Lamure did, that this motion took place before the opening of the cranium, as well as after it.

When the skull is opened by a wound, the dura mater still protects the brain, resisting inflammation, and giving the necessary and uniform

* These were Italian anatomists. Pacchioni was physician to Clement the XIth.

† Mém. de l'Acad. Roy. 1781.

‡ Duverney.

§ There is a distinction in the movement of the dura mater to be observed upon opening the skull; one depending upon the pulsation of the arteries of the brain; the other caused by an obstruction to the exit of blood from the cranium, depending upon the lungs. "On voyoit bien la pulsation des artères du cerveau, qui communiquoient "quelque mouvement à la dure-mère, mais ce mouvement n'avoit aucune symétrie avec "celui de la respiration. Fatigué de ne rien voir après avoir si bien vû, je comprimai "la poitrine de l'animal: aussitôt le cerveau se gonfla, evidemment par le reflux du "sang de la poitrine qui remplissoit la jugulaire.—Je lachai la poitrine, et le cerveau "redescendit."—Exper. 78. Mém. ii. par Haller sur le Mov. du Cerv.—"Il arrivoit, "pourtant, de tems en tems, et sans que cela continuât que le cerveau se soulevoit "dans l'expiration, et se laissoit repomper dans l'inspiration." Exper. 79. s. chat.

‖ By Coiterus, Riolanus, Bartholin.

¶ Diemerbroek.

** M. Schlichting Mém. des Savans Etrangers, 1774. Larry, Mém. present. à l'Acad. des Scien. par divers Savans Etrangers.

†† M. de Lamure; vide l'Acad. des Sciences, 1774.

support to the more delicate substance and vascular membrane of the brain; but when the dura mater is lacerated by the trepan, or punctured, or worn by the pulsation against the edge of the bone, there may be sudden hernia of part of the brain from coughing, or a rapid and diseased growth from the pia mater forming a fungus tumour. This fungus is occasioned by the taking away of that compression which the resistance of the dura mater gives when entire*; for by this yielding at a point, the whole force of the circulating blood is directed to it.

OF THE TUNICA ARACHNOIDEA.

While the dura mater is closely connected with the cranium, and in contact with the surface of the brain, but still unconnected with it, (except by means of veins entering the sinuses, and that only in the course of the sinuses,) the pia mater is closely attached to the brain, and passes into its inmost recesses. While the dura mater is firm and opaque, and not prone to inflammation, the pia mater is delicate, transparent, extremely vascular, and most peculiar in being easily inflamed.† Like the dura mater it is not endowed with sensibility‡; it is of great strength, considering its apparent delicacy.§

The pia mater, which was formerly considered as a simple membrane, consists in reality of two membranes, the TUNICA ARACHNOIDEA, or meninx media, and the proper pia mater, or tunica vasculosa.||

The TUNICA ARACHNOIDEA was discovered and commented upon by a society formed by Blasius, Sladus, Quina, and Swammerdam.¶ They called it Arachnoides, because of its extreme tenuity, comparing it to a spider's web. It was called also Membrana Cellulosa, from the appearance it took when they insinuated a blow-pipe under it, and blew it up, separating it from the pia mater.**

This membrane is without the pia mater; and while the pia mater sinks down into the sulci of the brain, this covers the surface uniformly, without passing into the interstices of the convolutions, or into the ventricles.††

This membrane is so extremely thin, that it cannot by dissection be separated for any considerable space from the pia mater, and, least of all, over the middle hemisphere of the brain. By the blow-pipe, indeed, we may raise it into cells, but it immediately subsides again; on the posterior part of the cerebellum, on the spinal marrow and base of the brain,

* I have seen in one day seven wounds of the head with fracture; of these, three had the bones thrust through the dura mater, and they died with fungus cerebri; the four others did well.

† Mr. Hunter on the blood.

‡ Haller. Oper. Minor. de Part. Corpor. Humani sent. & irrit.

§ Sir C. Wintringham, Exper. Essays. Taken comparatively it is stronger than the aorta.

|| There are many, however, who with Lieutaud consider the arachnoid coat as the external lamella of the pia mater.

¶ This was in 1665. I am, perhaps, not correct in saying they discovered it, for Varolius describes it plainly, covering the medulla oblongata.

** Ruysch Tab. 10. Epist. Anat. Prob. viii.

†† Haller. Elem. Phys. tom. iv. sec. viii. p. 7.

it separates spontaneously, and is very easily demonstrated.* It does not pass deep into the sulci of the brain, but unites them by an extremely delicate cellular texture.

OF THE PROPER PIA MATER, OR TUNICA VASCULOSA.

The pia mater is a simple membrane, without either tendinous, aponeurotic, or muscular fibres. It is extremely vascular, but it is transparent in the interstices of its vessels; it is the membrane which immediately invests and connects itself with the substance of the brain; and although delicate, it forms the support and strength of the cineritious and medullary substance. All vessels distributed in the body, however minute, are conveyed in membranes; the pia mater, therefore, follows, or rather conveys the vessels not only into the cavities of the brain, but to every part of its substance, it being intimately blended with it.† We see it more distinctly descending in strong plicæ into the interstices of the convolutions; nor is it into them only that it enters, but into every pore which conveys a vessel.‡ The pia mater, as it passes into the substance of the brain, divides and subdivides into partitions and cells, and every capillary vessel, and every mollicule of the substance of the brain, is invested and supported by its subdivisions. The pia mater is to the brain what the cellular membrane is to the other viscera and parts of the body; for it is the peculiar matter lying in the interstitious cellular membrane (as in muscles, bones, &c.) that gives the peculiarity of character to the parts§; the cellular membrane itself is nearly alike in all: therefore, in my judgment, the pia mater is properly enough considered by anatomists as a cellular substance.‖

Malacarne says, I am much inclined to consider it with the illustrious Haller, as being composed of laminæ like common adipose membrane, and that the extreme arteries ramify through its cells, for, with a blowpipe, we can raise it into cells like the common membrane; and if this be carefully done, the air may be made to pass from cell to cell, following the arteries in their course betwixt the lobuli, and in the substance of the brain.¶ We can follow the pia mater into the ventricles, by tracing it betwixt the posterior lobe of the cerebrum and the cerebellum, where it forms the velum interpositum of Haller, and passes under the

* F. Ruyschii Responsio ad A. os Goelecke Epistol. ix. See Bidloo, table 10; but the membrane is so delicate, that it can be but very imperfectly represented by engraving. See also Sandifort Thesaur. vol. ii. p. 291.

† Columbus, the assistant of Vesalius, and afterwards professor in Rome, explained this intimate intertexture of the pia mater with the proper substance of the brain, so far back as 1559.

‡ When we tear off the pia mater from the brain (for it cannot be called dissection), it does not adhere merely at the sulci, but to the whole surface of the convolutions; and every where small vessels enter, and with these vessels descends also the lamina of the pia mater.

§ See Leeuwenhoeck, Epist. Phys. xxxiv.

‖ Bergen. Program. de Pia Mater. See Haller Anat.

¶ See Albinus Ann. Acad. vol. i. lib. i. cap. xii. and the beautiful plate iii. See Ruysch. tab. 8. Epist. Anat. vii. & tab. 15. Such is the profusion of vessels distributed to inconceivable minuteness, that it has been considered as entirely composed of vessels; it has received the name of chorion, from the membrane of the secundines, Galen de Usu Part. l. viii. cap. 8. Malacarne, part. i. sec. 243.

fornix. We can follow it also into the posterior horn of the lateral ventricles from the base of the brain, where the branches of the middle artery of the cerebrum pass into the lower part of the choroid plexus; we trace it also into the bottom of the fourth ventricle. The pia mater lining the ventricles is more delicate, and less vascular, than that seen upon the surface and betwixt the convolutions of the brain.

It has been said that the ventricles of the encephalon served to increase the surface of the pia mater, and that whatever purposes are served by that membrane and its vessels on the surface of the brain, we must suppose the same performed by it within the ventricles.* This seems more like a satisfactory conclusion than it really is.

As the tunica arachnoidea is of a peculiar nature, and has few, if any, vessels, and as it covers the external surface of the brain only, it seems to me probable that this membrane is the cause why effusions in the ventricles are so common, and why fluids are so seldom found betwixt the surface of the brain and the dura mater. When by the diseased action of the vessels of the pia mater on the surface of the brain, an effusion is thrown out, it very seldom lies unconfined upon the surface; but frequently fluids are contained in sacs of the arachnoid coat, betwixt the convolutions of the brain, or raise pellucid vesicles upon the surface. The want of a tunica arachnoidea upon the pia mater of the ventricles may be a cause of the fluids being so much more readily secreted into these cavities.

The raising of the arachnoidea into vesicles, by the action of the vessels of the pia mater, is rather an argument for the distinct nature of these membranes. The tunica arachnoidea is raised by the action of the vessels of the pia mater, as the cuticle is raised into blisters by the inflammatory action of the vessels of the cutis, while no other membranes of the body present such an appearance in their disease. They inflame, indeed; they thicken; their laminæ become more distinct, or their cellular substance fills with water, or hydatids are formed in them; but this appearance of water secreted under the tunica arachnoidea is peculiar to the surface of the brain.

OF THE SUBSTANCES OF THE BRAIN.

The cerebrum and cerebellum consist, as we have said, of two substances very different in colour, viz. the cineritious and medullary matter, first described by Picolomini. The cineritious, or ash-coloured matter, forms the superficial or outer part of the encephalon, and is therefore called also the cortical part. This cortical matter is of a reddish grey colour, and semitransparent, but varies considerably†; in the crura cerebri it is very dark; in the pons varolii it is redder; in the corpora olivaria‡ it is yellower. The consistency of this matter also varies con-

* Dr. Monro's Nervous System, chap. vi.

† Cuvier describes it black in some places.

‡ Vicq d'Azyr.—" Exterior cerebri totius facies, donec in spinalem medullam abeat, " plerumque colore est subrubride cinereo vel languide russeo. Fusciora sunt cerebra " sanguine ditia, *e. g.* hominum apoplexia enectorum, vel hominum crassioris san- " guinis; pallidissina vero sunt cerebra hydropica vel hominum pituitosorum vel hæ- " morrhagia mortuorum. Dubior procul color cerebri sanguinis temperaturam sequi-

siderably in different parts: it is soft in the base of the brain, betwixt the optic nerves and anterior commissure, and in the third ventricle. The medullary matter is chiefly in the internal part of the brain, forming a kind of nucleus or white central part; but in many parts of the brain, there is a mixture of these which form striæ*; and in some of the eminences, the internal part is cineritious, while the external part, or what we might here call the cortical part, is medullary.

The cortical or cineritious substance does not blend gradually with the white medullary matter, but on the contrary, their line of distinction is abrupt: and even an intervening substance has been observed. In inflammation of the brain, particularly, it has been said, that this third substance has been found. This may be merely the effect of light upon the union of the two substances. We, however, often observe an appearance of successive coloured circles upon the edge of the medullary matter of the arbor vitæ, in the cerebellum.

It has been asserted by M. Ludwig† that the masses and striæ of the cineritious substance, dispersed through the internal parts of the brain, have a communication with each other. This, however, is denied, by Vicq d'Azyr.‡ He conceives, that the cineritious substances of the pons varolii, or of the corpora olivaria, have no communication with the cineritious substance in any other part of the brain; and that in several parts of the brain the cineritious substance is surrounded and isolated by the medullary matter. Its great importance (which should never have been doubted) has been deduced from its being so generally found towards the origin of the nerves.§

The cineritious substance seems to have a greater proportion of blood circulating in it than the medullary substance. Its vessels come by two distinct routes, partly from the extremities of those arteries which appear in large branches upon the surface of the brain, and partly by vessels which penetrate through the medullary substance from the base of the brain. Ruysch and Albinus have made the most minute injections of this part of the brain. The former conceived it to consist entirely of vessels; but Vicq d'Azyr and Albinus found always, in their experi-

"tur, et ideo pallidius est infantibus, quam adultis." Sœmmerring Hum. Corp. Fab. vol. iv. p. 11. As Boerhaave never saw, or observed, but merely imagined, he ought not to be regarded; now we may look for a better purpose into Albinus. Annot Academ. vol. ii. c. 12.

* Thus the cineritious substance is mixed with the medullary matter in the corpus callosum, in the corpora striata, the thalami nervorum opticorum, in the tubercula quadrigemina, the eminentia mamillaris; in the crura cerebri; in the pons Varolii; in the corpora olivaria, and medulla spinalis.

† De Cinerea Cerebri Substantia. Leipsiæ.

‡ Hist de l'Acad. Roy. an. 1781, p. 507.

§ Il faut que les usages de la substance grise soient très-importans; car, indépendamment de la portion de cette substance que les circonvolutions contiennent, et qui semble appartenir à la masse blanche du cerveau, on en observe des amas plus ou moins considérables près des diverses origines des nerfs: ainsi près de la première et la deuxième paire, sont les corps striés et les couches optiques: la troisième paire est près d'un espèce mamillaire que je décrirai ailleurs: la quatrième paire fort au des-sous des tubercules quadrijumeaux, dont le noyau est composé de substance grise; la cinquième, la sixième, la septième, se trouvent aux environs de la protuberance annulaire, où la substance grise est mêlée avec la blanche: la huitième et la neuvième sont placées près de l'éminence olivaire, où j'ai observé un mélange particulier de substance grise. Mém. de l'Acad. Scien. an. 1781. p. 507.

ments, that a great proportion of it remained colourless after the most minute injection. It is, indeed, very improbable, that so soft a body should be entirely composed of vessels. How, for example, can we suppose the commissura mollis, or cineritious matter on the sides and bottom of the third ventricle, or almost transparent lamina, which we find in some parts, to be composed of vessels ?*

The white MEDULLARY SUBSTANCE is a pulpy mass. We observe no peculiarity of structure in it towards the surface of the brain, where it is contiguous to the cortical matter ; but towards the origin of the nerves it takes a more fibrous and striated appearance. This appearance of fibres is not owing to any peculiarity in the medullary matter, but to the manner in which the pia mater involves it. The medullary matter, being chiefly internal, has every where through the brain a communication, as from the fore to the back part, from the upper part to the base.†

OF THE MINUTE STRUCTURE OF THE BRAIN.

The opinions regarding the structure of the brain have had a dependence on the general doctrines of the structure of the secreting organs, and it is, of course, connected with the disputations of Malpighi and Ruysch. The doctrine of the glandular nature of the brain, and the belief of the nervous fluid being a secretion, has, in all ages, formed the basis of the most favourite theories.‡

Malpighi found, on throwing in black and fluid injection, that there remained always particles colourless, and to which the injection did not penetrate. He conceived these to be glandular folicules, and that the cineritious substance of the brain consisted of this folicular or glandular structure, while the medullary matter of the brain was merely the fibrillæ of the excretory duct. This opinion was founded on conjecture, with but a very poor show of experiments. By boiling the substance of the brain in oil, he found it take a granulated appearance, as if formed of small grains, or little glands, as he presumed.§

Such was the received opinion until Ruysch with a despotic authority swayed the opinions of physiologists : he alleged, in proof, only his own experiments and preparations, in which other anatomists could not follow

* The centrical and cortical substance of white blooded animals present no difference of colour. *Cuvier.*

† Meckel found, upon comparing the brains of an European and of a Negro, that the medullary matter differed very much in colour. In the Negro, instead of the whiteness of the European, the medullary matter was of a yellow colour, and nearly like the cineritious matter ; he observed, also, that this very peculiar distinction of colour was only to be observed when the section was recently made, and that the darker colour of the medullary matter became fainter when exposed to the air.

‡ Indeed this doctrine of the glandular nature of the brain has descended from Hippocrates—"Caput quoque ipsum glandulas habet ; cerebrum enim est ut glandula, "album est et friabile," &c.

§ "Pedamentum, supra quod posita est philia in qua conservatur porti cerebri in liquore, quam decoxi in oleo olivarum per horas, sicuti, facere assolet Dr. Vieussens. "Ea autem plane *inutilis et perversa est preparatis*, nam nihilum quidem vasculosi "visui occurrit post decoctionem in dicto oleo, et quod unusquisque tentare potest, ita "ut inventor neutiquam habendus sit Dr. Vieussens. Sc. quod cerebri cortex nil sit, "nisi extremitates vasorum sanguineorum : in ea autem nemo hactenus (quod sciam) "me imitari poterit aut analogum quid fecit." Ruysch. Thes. An. x. No. xxxii.

nor refute him, and therefore, perhaps, they acquiesced. His most unanswerable and most insulting argument was "veni et vide."*

According to Ruysch, the cortical substance of the brain is entirely vascular, and has no appearance of a glandular or follicular structure; nay, he conceived it to be entirely composed of arteries.† This opinion Albinus confuted; and Malacarne observes, though we suppose the extremities of the arteries of the cineritious substance to be more minute than those which are distributed to the microscopal corpuscula of the smallest visible insect, there must still remain some part which is not composed of vessels; and in regard to the veins of the cineritious substance we may appeal to Albinus, who, from the substance of the brain, finds many veins connected with the arteries of the cineritious substance when he carefully lifts the pia mater. But there is this peculiarity in the distribution of the blood vessels of the brain, that though the cineritious substance be the most vascular, yet, in the medullary matter, we see the vessels with large open mouths, and more distinct than in the cineritious substance. In following the blood vessels from the base of the brain into the medullary substance, we see them distinct, and of considerable magnitude; but when they are about to enter the cineritious substance, they disperse into minute branches.‡ In the same manner those arteries, which are carried into the sulci of the surface by the pia mater, branch into extreme minuteness before they finally penetrate the cineritious substance.§

Leeuwenhoeck‖ observed, in the cortical substance of the brain, a pellucid, crystalline, and, to appearance, oily matter; he calls this, therefore, the *substantia pellucida et vitrea*. When he had put a small portion of this under his glass, he saw a fluid, which he at first conceived might have escaped from the globules that were necessarily cut by the knife. This fluid also he found to consist of very minute globules, thirty-six times less than those of the blood.¶ These small globules he conceived to have probably constituted a fluid, which, during the life of the animal, was moveable, and in vessels, though now in death congealed and fixed.**

* "Milites quando hostium adventum audiunt, clament ad arma! ad arma! sic ego "dico hic, ad visum! ad visum!" Responsio ad J. Ch. Bohlium.

† Vieussens was latterly of the same opinion, and is accused of plagiarism by Ruysch. Accordingly, we find, that in some parts of his works he describes the glands and ducts of Malpighi.

‡ Leeuwenhoeck saw, in the substance of the brain, but especially in the cortical substance, red blood vessels, but so delicate that he could not comprehend how the globules of the red blood could pass along them; and what appeared more particular, they were of a deeper colour than the red particles themselves; for when seen singly, they appeared to have very little colour. This he explained by an experiment made upon a louse. After it had sucked blood very plentifully, he observed that the blood was broken down by digestion, and conveyed through the limbs, hair, and horns of the creature, so as to make it universally red. So here he conceives that the globules of the blood may be broken down and altered in their shape to enter the minute vessels of the brain.

§ Malacarne, Part ii. sect. 18.

‖ He was born in Delft, in Holland, 1632, and died in 1723. He is celebrated for his microscopical discoveries; his papers are chiefly in the Transactions of the Royal Society of London, about the year 1674.

¶ Anatomica Contemplatio, 30. Ridley, Anat. Cerebri, cap. xi.

** Among these globules of which the brain is composed, he saw also the globules of the blood, which it was easy to distinguish by their roundness. These red globules he supposes had escaped in consequence of the minute vessels having been cut by the knife.

The colour of the cortical substance he found to depend upon the minute ramification of the vessels, which were of a dark brown colour, while, in the medullary part, they were clearer and more transparent. Independently of this distinction of vessels, he could observe little difference in the medullary and cineritious substance; the refraction of the rays of light amongst the transparent globules being the cause of the whiteness of the former.

R. Della Torre*, in his microscopical observations, describes globuli in the brain; he says, that he saw them floating in a pellucid viscous fluid. But Prochaska† thinks Della Torre must be mistaken in this: for when he took a small portion of the brain, he saw it consisting of innumerable globules, which continued to adhere to each other, even after three months' maceration in water; and thence he concludes, that it could not be as R. Della Torre conceived, that these spherical bodies moved from the brain on towards the extremities of the nerves; nor do these bodies lie imbedded in a glutinous fluid (he continues), but they are connected by the extremely minute and pellucid sepimentæ of the pia mater, and by the vessels which pervade both the cortical and medullary matter, and which nourish as well as support and connect these corpusculi.

Fontana‡, on submitting a portion of the medullary matter to the microscope, thought he discovered it to consist of small winding tubes filled with a transparent gelatinous humour. This he chose to call the intestinal substance of the brain.

Prochaska§ cannot, from his own observations, determine whether the globular bodies of Della Torre be convoluted vessels, or what they are. R. Della Torre had observed, that they were largest in the cortical part, less in the medullary substance, still diminishing in the medulla oblongata, and least of all in the nerves; but succeeding observations did not support this assertion.‖ Malacarne expresses himself to be nearly of the same opinion in regard to the vesicular structure of the cortical substance of the brain. The minute processes of the pia mater, says he, embrace and support the medullary substance, which is surrounded with a matter of a darker colour, and less distinctly fibrous, but not less essential, and which is composed of corpuscules, that in figure and arrangement resemble the vesicles of the pulp of a lemon.

Many authors endeavour to support their conjectures regarding this vesicular structure of the brain by morbid dissection. But in this edition I have thrown out the detail of their opinions, as well as all reference to their authority.

I have given more place to these observations on the minute structure of the brain than in my judgment they deserved, rather to prevent the repetition of the folly by such as might conclude they were pursuing an unexplored path, than from any hope of the subject proving useful.

When the brain is examined in the fœtus of the early months, although

* Nuove Oservazione Microscopiche, Nopoli. 1776.

† Tract. Anatom. de Struct. Nervorum.

‡ Fontana's Treatise on Poison, and on the Primitive Structure of Animals, translated.

§ Professor of Anatomy at Prague.

‖ This was certainly a theoretical deception; it is like the accurate observation of Fracassati, who could distinguish a difference of taste in the medullary and cineritious substance of the brain.

the substance of the brain is extremely soft, and even of a fluid consistence, the membranes and vessels are fully formed, exquisitely minute, and perfect in all their processes, so that they give form and firmness to the brain. As the brain is perfected, and as it is covered by a firmer bone, it acquires more consistence and firmness. With this firmness it does not acquire strength; for the brain of a child will suffer more injury without destruction of organization, than the brain of an adult. The substance of a child's brain is soft and yielding, while the bones of the cranium are loose and yielding, and for the same purpose, to admit the compression of the head at birth.

OF THE EXTERNAL DIVISIONS OF THE BRAIN,

AND

OF THE PARTS SEEN WITHIN IT ON DISSECTION.

It has been usual to disengage the brain from the skull, and to examine it in its different aspects; and looking upon it thus to divide it, first into the *cerebrum* the greater and anterior brain, and the *cerebellum* the lesser and posterior brain, and into a third part which appeared obviously the part common to both, viz. the *medulla oblongata.* The medullary masses of both cerebrum and cerebellum being visible, as it were descending in form of *crura*, they seem, and have always been described as combined in the *nodus cerebri*, to form this prolongation into the third grand division, the *medulla oblongata;* and this last portion, though much less than the other grand divisions, has always been held important from its manner of formation or its connections.

After this first division into cerebrum, cerebellum, and medulla oblongata, anatomists have made a further subdivision of the cerebrum into hemispheres, viz. those two grand lateral divisions visible on the upper surface; and turning these hemispheres up so as to exhibit the irregularities on their lower surfaces, they have made the further divisions into *anterior*, *middle*, and *posterior lobes* of the cerebrum.

The cerebellum is described in the same manner; first we distinguish a central part, sometimes called *corpus vermiforme*, and two great lobes or hemispheres, which, indeed, constitute the longer portion of the body in the human subject; but which are, notwithstanding, parts superadded to the original and fundamental part, as seen in the lower animals.

The medulla oblongata is very obviously divided by a rapha on the fore and back part into two lateral portions.

Having noticed these divisions, we proceed to inspect the interior of the brain.

To explain the connections of the several parts of which the brain consists, there have always been two methods; the one commencing with the base of the brain, splitting and turning up the crura, and prosecuting them in this course inwards; the other by sections commencing on the upper part of the cerebrum, and dividing its substance to inspect the cavities.*

* These two methods were followed by Mr. John Bell, in his Lectures, and have

OF THE CAVITIES OF THE BRAIN IN GENERAL.

Before giving the demonstration of the ventricles, I must affirm, that there are no cavities in the brain, and no surfaces which can correctly be called internal. The walls of the ventricles lie in contact: there is no space betwixt them, and, therefore, in correctness of language, no cavity. But I have another meaning in saying that there are no internal surfaces. To comprehend the proper structure and relation of the parts of the brain, it is necessary to recollect that these cavities can be laid open without making a breach into the proper substance of the brain, and, therefore, that they are, in fact, the surfaces continued from the exterior convolutions of the brain, and the ventricles, therefore, are formed by the portions of the brain rolled up and adhering at certain parts by the pia mater.

There are within the brain many tubercles and irregular surfaces, of which it is infinitely more difficult to convey an idea by description than of the external parts. The surface of the cavities or ventricles of the brain is naturally bedewed with a fluid or halitus, which flows from the general surface of the ventricle, and from the plexus choroides. This moisture preserves those surfaces from adhesion: during life and health it is not accumulated so as to form a fluid; but in many diseases, and after death, it is effused or collected into a fluid. The external convolutions of the brain we have seen to be cineritious on the surfaces; the internal surface of the brain may be considered also as forming convolutions; but they are chiefly medullary, and are more irregular, or rather have a greater variety of shape, than those of the outer surface.

In regard to the use of the ventricles of the brain, since the hypotheses of the older physicians have been tacitly rejected, no opinion has been offered, except this, that "they seem to be made of a necessary consequence, and towards the greater use and distinction of parts;" or, as we have already had occasion to mention, that the ventricles serve to increase the surface of the pia mater, and that whatever may be the purposes which are served by that membrane on the surface of the brain, we must suppose the same to be performed by it within the ventricles. But this is a conclusion which may not be altogether satisfactory to an inquisitive mind.

It is necessary to take into consideration the general peculiarities of

always been followed by me, since I gave public lectures; and they have been followed by the old anatomists, and must be followed while the object of this study is acknowledged to be, first, to understand the connection, and, secondly, to understand the morbid anatomy of the brain.

Those who would neglect the method of dissection from above downward, are equally ignorant of the uses of the anatomy of the brain, with those who in fine enthusiasm declare their admiration at Dr. Gall's and Dr. Spurzheim's demonstration from below upwards. These gentlemen say, they are vindicated in their ignorance, since the brain never was dissected before! The demonstration of the connection of the parts of which the brain consists, and the relation of the parts to the origin of the nerves, is necessary to the comprehension of the structure, and is very proper. But the dissection of the brain with the knife, opening its cavities to observe its interior structure, in their natural and undisturbed position, is the more important and ultimate object, since the whole jet of the enquiry is to enable us to detect the appearance of disease.

the brain: we find that within the skull there is no adipose substance, though it pervades every other part of the body. We at once see a reason for this. It is evident that as the fat is incessantly undergoing changes (being alternately absorbed and deposited); as at one time it is deposited in greater quantities, and at another absorbed; as it is in perpetual variation according to the prevailing habits of the body, the proportion of exercise taken, or the state of the health; its continual changes would have the very worst consequence upon such a part as the brain; that if accumulated, it would oppress the circulating vessels; if rapidly absorbed, it would be followed by accumulation or surcharge of the vessels; for the skull does not allow of distention, nor is it possible that the cavity of the cranium can admit of depletion.

The ventricles of the brain are in their natural state merely surfaces in contact. The forms of these internal surfaces are resulting from the internal conformation of the substance, as the great external convexities are, and as the superficial convolutions are; I have just said, that we can arrive at these interior surfaces by splitting up the divisions of the brain without tearing the substance of it.

The next enquiry is, Why this evident difference of surface within and without the brain? The *cavities*, as we shall continue to call them, have no arachnoid coat, they have, therefore, secreting surfaces. Here is the real distinction of the external and internal surfaces of the brain. It has long appeared to me that these cavities, and the provision for secretion into them, had a very particular influence, in preserving the due relation of the parts of the brain, which would otherwise be deranged or unequally pressed. A collection of water in the ventricles of the brain is, perhaps, the most frequent of all diseased appearances, and when within the ventricles it is much less injurious than in the external surface; when collected on the surface, under the tunica arachnoidea, it is ever attended with oppression of the faculties.

It is not to be supposed that the ancients, so fertile in their hypotheses, and so easy in their proofs, could neglect the evident importance of the ventricles of the brain. We accordingly find that the spirits were manufactured in these cavities; that they were the "spirituum animalium officina," whence the spirits were conveyed over all the nervous system.* They were again degraded from this higher office, and became the mere receptacles of the excrementitious matter of the brain (meras cloacas esse asseruerint†); and Willis seems inclined still further to degrade the importance of the ventricles, by considering them merely as of secondary importance; or rather as resulting solely from the accidental conformation of the brain.‡ Again, we find it a prevalent opinion that the ventricles contained air; that the air supported the soft medullary substance

* Lately, by chemical aids, (which make the cineritious substance black, or dark brown, while the medullary matter remains white or takes a slight greenish tinge,) the origin of many of the nerves have been traced into the substance of the brain even to the surface of the ventricles, which has given occasion to the revival of similar ideas of the use of the ventricles.

† Willis Cereb. Anat. p. 32.

‡ "Porro si quis cerebelli fabricam exacto considerat, et serio perpendit, quod hi ven- "triculi non ex primaria naturæ intentione efformentur, at secundario tantum et acci- "dentaliter de cerebri complicatione resultent." &c.

of the brain; and that it gave motion to the whole mass, so as to circulate the spirits in the substance of the brain.*

OF THE CORPUS CALLOSUM AND CENTRUM OVALE OF VIEUSSENS.

The CORPUS CALLOSUM is a medullary body which is a centre of communication; or, it is the great commissure† passing betwixt the hemispheres of the cerebrum‡: it is seen without incision by merely separating those hemispheres with the fingers. It is a white body, firmer than the rest of the medullary substance. It is but slightly convex upon its upper part, but turns convex downwards upon the fore and back part. As the corpus callosum is the continuation of the internal medullary substance of the brain, it is superfluous to say that it is continued down, anteriorly, into the medullary matter betwixt the corpora striata, terminating in its pedunculi; or backwards, that it is continued with the fornix and cornua ammonis and the surface of the posterior prolongation of the lateral ventricle.

We see upon the surface of the corpus callosum two medullary lines considerably raised, running parallel to each other§ in the length of the body. Betwixt these salient lines there is of course a kind of rut, called sometimes the rapha, or suture, which may be considered as dividing this body into two equal parts, and which, in truth, forms the accurate division of the two sides of the whole brain.||

Other lines, less elevated from the surface, are to be observed running across these, as if passing from one hemisphere to the other. If the corpus callosum be cut horizontally, and the section be continued into the substance of the hemispheres, we still can perceive those transverse lines, and observe them to be lost in the medullary matter of the hemispheres.¶

* Malpighi.

† Commissure is a term applied generally to those tracts of medullary matter, which passing through the brain are supposed to be media of communication.

‡ Willis, conceiving the spirits to lodge and circulate in the superficial convolutions of the brain (upon the conformation of which depended the capacity or ability), gives to the corpus callosum the property of collecting and concentrating the spirits, "quasi "in *publico emporio* commorantur;" and here they were depurated by repeated circulation.—The language in which all this is delivered conceals the absurdities of the doctrine: "Spiritus recens nati undequaque ab extima hujus corporis ora versus an- "teriorem istius corporis callosi partem, ubi crassimum existit, perpetim blande scatent, "ibidemque, si opus fuerit, aut imaginationis actui impenduntur, aut medullæ oblon- "gatæ crura subeuntes, appendicem nervosam actuant et inspirant." What remains superfluous of the spirits returns backwards and circulates through the fornix, and is still farther subtilized, "hoc motu subtiliores quosdam phantasiæ actus peragunt."

§ They are not strictly parallel in all their length: we find them often separated both upon the fore and back part; but generally more separated upon the back part, and even sometimes they are curved.

|| In which conceit Duverney calls this "clef du cerveau," from its being the centre of communication. Tom. i. p. 39.

¶ The necessity of explaining paralysis and convulsive motions of that side of the body opposite to the side of the brain injured, have made anatomists attend to those transverse lines, in the hopes of finding such a decussation of these lines as would account for it. Sabbatier says, they have brought themselves to believe that there was a decussation, but after careful investigation he could find no such thing. See Winslow. Ludwig (de Cinerea Cerebri, sub. p. 5.) observed striæ of cineritious substance in the corpus callosum. See also Gunz, and Haller.

This body is properly called the great commissure (*commissura magna*), for it is the great part of medullary matter which, formed by transverse striæ, incorporates and unites into one whole the two lateral divisions of the cerebrum.

CENTRUM OVALE OF VIEUSSENS.

The CENTRUM OVALE is merely the appearance which the white and internal part of the cerebrum takes when the brain is cut horizontally on the level of the corpus callosum; for then the corpus callosum is the centre of the great medullary mass of the cerebrum; and the cineritious matter, being on the external edges only, forms the central white mass into an irregular oval.

THE SEPTUM LUCIDUM.

The two lateral ventricles lie under the corpus callosum and medullary centre; they are divided by a partition, which descends from the lower surface of the corpus callosum, and rests upon the fornix. This septum of the ventricles is transparent, and consists of two laminæ, and each of these consists of medullary and cineritious matter.* Betwixt these laminæ is the cavity of the septum lucidum.† The size and shape of this cavity differs in a variety of subjects. It is of a triangular shape, and from eighteen to twenty lines in length.‡ It has a fluid exhaling into it like the ventricles, and is by some counted as a fifth ventricle: according to Santorini it opens in the base of the brain, opposite to the union of the optic nerves. Vieussens describes it communicating with the third ventricle.§ Winslow also has seen it reaching a great way backwards, and conceives it to open into the third ventricle. Sœmmerring describes it as large in the middle, contracted backwards, and having no communication; but he asserts that it is shut in on every side.‖ In the base of the brain we find a narrow longitudinal sulcus betwixt the pedunculi of the corpus callosum. In the bottom of this cavity there is a medullary lamina, which Vicq d'Azyr calls "*Cloison à la cavite du septum lucidum.*" And the sulcus he calls "*Fosse de la base du* SEPTUM LUCIDUM." By a careful section of this medullary substance we lay open the cavity of the septum lucidum.

LATERAL VENTRICLES.

Under the corpus callosum and medullary centre, and on each side of the septum just described, are the lateral ventricles. They are distinguished into right and left. They are of a very irregular shape, stretching into three prolongations or cornua, whence they have the name of

* Vicq d'Azyr.
† It was discovered by Silvius. See also Santorini.
‡ Sabbatier.
§ "In qua pellucidam non raro reperimus aquamque haud dubie in tertium illabi- "tam ventriculum." Vieussens de Cerebro, p. 59.
‖ De Corporis Humani Fabrica, tom. iv. p. 55.

tricornes. They are the great ventricles of the brain; the third and fourth being comparatively very small. What may be considered as the principal chambers of these ventricles are formed betwixt the corpus callosum, the medullary substance forming the centrum ovale, and the convexity of the corpora striata and thalami nervorum opticorum. Following the cavity forwards, we find what is called its ANTERIOR HORN or sinus; it is formed betwixt the more acute convexity of the corpus striatum and the anterior part of the corpus callosum: the posterior horn stretches into the posterior lobe of the cerebrum, which rests upon the tentorium. It makes a curve outwards, and at the same time inclines a little downward.

The INFERIOR OF DESCENDING HORN is like the continued cavity of the ventricle: it takes a curve backwards and outwards, and then, turning forwards and downwards, it descends into the middle lobe of the brain.

The lateral ventricles do not terminate in the others by any of those prolongations; but they communicate, upon a very high level, with the third ventricle and with each other, by a wide opening formed under the fore part of the arch of the fornix. This communication we easily find by following the choroid plexus forward and under the fornix; it is a space betwixt the most anterior part of the convexity of the optic thalami and the anterior crura of the fornix.

OF THE PARTS SEEN IN THE LATERAL VENTRICLES.

The FORNIX is a medullary body, flat, and of a triangular shape: its lower surface is towards the third ventricle: its lateral margins are in the lateral ventricle. On its upper surface it supports the septum lucidum, or partition of the two lateral ventricles, and under its most anterior part is the communication betwixt the lateral ventricles and the third ventricle.* One of the angles is forward, and the other two towards the back part: it rests chiefly upon the thalami nervorum opticorum, but it is separated from them by a vascular membrane, which is continued from the external pia mater, and which stretches into the brain betwixt the posterior part of the corpus callosum and tubercula quadrigemina. This membrane connects the plexus of the lateral ventricle. The fornix leaves, betwixt it and the convex faces of the anterior parts of the corpora striata, a triangular space, which is in part occupied by the septum lucidum.

The extremities of this body are called crura. The posterior crura, coalescing with the corpus callosum, (which is continued downwards posteriorly,) are prolonged upon the edges of the hippocampi: and the anterior crura, forming the anterior angle, being close together, bend downwards before the anterior commissure, and are connected with it: they then bend round the thalami, and may be traced into the crura cerebri; or, according to others, they form the corpora albicantia.†

* Of this communication see farther in the Anatomy of the Brain, illustrated by engravings.

† Two white bodies seen on the base of the brain behind the infundibulum. [The crura of the fornix very unequivocally commence within these processes.] J. D. G.

Those pillars, or crura of the fornix, are fibrous in some slight degree like a nerve. This is to be observed by cutting them either across or in their length.*

Upon the lower surface of the fornix there are lines like those of the corpus callosum, and which are erroneously conceived by many to be the impression of the vessels of the velum. It is this lower surface of the fornix which is called LYRA, CORPUS PSALLOIDES, it being compared to a stringed instrument.†

OF THE HIPPOCAMPI, OR CORNUA AMMONIS, AND OF THE TENIA HIPPOCAMPI.

These are parts to be seen by following the posterior crura of the fornix. They are covered by a soft vascular substance, the plexus choroides. We have observed, that upon the back part the fornix adheres to, or is continuous with, the corpus callosum. We shall find also that its posterior crus on each side divides into two lamina of medullary matter: the one of these is continued into the cornu ammonis, and the other (being the anterior of these portions) forms the tenia hippocampi.

The hippocampus is narrow at its commencement in the posterior crus of the fornix‡; but is enlarged as it descends, following the course of the inferior prolongation of the lateral ventricle towards the base of the brain. It is, indeed, merely a relief or particular convexity of the floor of this lower horn of the ventricle, like a pad. The inferior extremities of the hippocampi on each side turn inwards, pointing to the crura cerebri, and taking thus a curve like a ram's horn.§ In its whole extent the hippocampus consists of an internal cineritious substance, and a superficial layer of white medullary matter.‖

The TENIA HIPPOCAMPI, OF CORPUS FIMBRIATUM, is the prolonged margin of the fornix: it is merely the thin edge of the hippocampus, which follows in the whole of its circuit, and terminates in an acute

* Vicq d'Azyr, Acad. Scien. 1781, p. 517.

† The prevalent idea amongst the older authors regarding the use of the fornix was, that it acted like a ligament binding together the internal parts of the brain; or that it supported the incumbent weight of the upper parts of the brain from pressing upon the lower. "Verum alter atque iste insignior fornicis usus esse videtur quem modo "innuimus; nempe, ut spiritus animales per ejus ductum ab altera cerebri extremitate "ad alteram immediate transeant, atque ita quasi per pelicani rostrum in sui ipsius ven- "trem intortum circulentur." Willis.

‡ In speaking of the origin of the hippocampus as from the fornix, I mean simply that the student having gained the knowledge of one part of the brain may trace the others from their relation to it; and that, understanding the situation and relation of the fornix, he traces its crura until he finds them terminating in the hippocampus. We might fully as well say that the hippocampi are formed from the posterior part of the corpus callosum, for they are the same medullary matter continued.

§ Betwixt the extreme point of the hippocampi and the crura cerebri (when the base of the brain is turned up) we can insinuate the probe into the inferior horn of the lateral ventricle, without piercing the substance of the brain, but merely tearing the pia mater.

‖ "Vers la partie inférieure et postérieure du corps calleux, on trouve, de chaque "côté, un petit bourrelet de substance grise qui se prolonge dans l'épaisseur de l'hypo- "campe, dont il fait partie; ce bourrelet est recouvert dans son principe par une lame "de substance blanche." Vicq d'Azyr, loc. cit.

point near its bulbous extremity in the inferior horn of the lateral ventricle.

The LESSER HIPPOCAMPUS, or COLLICULUS, is a relief or convexity in the floor of the posterior horn of the ventricles, which may be traced backwards from the crura of the fornix. It has the same relation to the fornix which the greater hippocampus has, and lies in the posterior horn or prolongation of the ventricle into the posterior lobe of the brain, in the same way in which the great hippocampus lies in the inferior horn or prolongation of the ventricle into the middle lobe of the brain.

The VELUM and PLEXUS require to be taken away before we can fully understand the situation of the third ventricle, or of those tubercles which are but partially seen in the lateral ventricles.

The VELUM VASCULOSUM lies in the centre of the brain, and extends from the surface inward betwixt the posterior lobes of the cerebrum and the cerebellum, then betwixt the corpus callosum and nates and testes, and then under the fornix. It forms thus a great communication betwixt the external and internal membranes of the brain. As it lies under the fornix, that medullary lamina adheres to it, while the velum again adheres to the thalami nervorum opticorum, which are beneath it. Its margin seems to be terminated laterally by the choroid plexus (when we view it after raising the fornix); but it is not strictly so, for the choroid plexus is continued with the membrane of the ventricles, and has no where a termination. For the vascularity of this membrane, turn to what has already been said in speaking of the internal veins of the brain.

Seeing how the plexus choroides are formed and connected, they cannot be strictly said to have either beginning or termination; they are the connected folds and plicæ of the internal membrane of the ventricles loaded with vessels; but to describe them intelligibly, we must, notwithstanding, trace them in this manner. The PLEXUS of the LATERAL VENTRICLES rise from the bottom of the inferior horns of these ventricles (called the digital cavity), betwixt the pedunculi or crura cerebri and the termination of the hippocampi; they lie like fleshy bodies in that lower horn. As they rise into the superior level, they are at their greatest size (there they have often a diseased appearance, being hard, and as if scirrhous, or full of little vesicles or hydatids); they then pass forwards and inwards, diminishing in thickness, and approaching gradually until they coalesce under the fornix, and immediately behind the communication betwixt the ventricles. The PLEXUS OF THE THIRD ventricle, formed by the union of those of the lateral ventricles, turns back upon the lower surface of the velum, and is comparatively very small. If my reader has any difficulty in comprehending the relation and place of the *velum interpositum*, he has only to notice the place of the choroid plexus, lying, the one in the left, and the other in the right lateral ventricle; then he is to lift the fornix, and he will discover a vascular membrane passing betwixt the plexus of the right and left sides. This is the *velum* or *diaphragma*.

The CORPORA STRIATA are smooth, cineritious convexities in the fore part of the lateral ventricle. They are somewhat of the shape of a pear; they are obtuse forwards; they approach each other towards the

fore part with a regular convexity, and they are narrow as they pass backwards, separating at the same time; their posterior extremity being as it were pushed out by the thalami nervorum opticorum. These last lie more under the back part of the fornix, and are more concealed when the lateral ventricle only is laid open. The corpora striata are so called from the intermixture of the medullary matter in their substance, which gives the appearance of striæ when they are cut. They descend down to the base, and are intimately connected with the crura cerebri. The striæ of medullary matter pass from above downwards; they therefore appear in the horizontal sections of this body like white points. A superficial horizontal section of the corpora striata shows those striæ connected with the medullary matter of the middle and posterior lobe. A deeper incision brings into view a mass of cineritious substance betwixt those striæ and the medullary matter of the middle lobe. Another incision shows the course of the striæ altered, and brings into view the connection betwixt the corpora striata of each side, by means of the anterior commissure.*

The COMMISSURA ANTERIOR is a cylindrical medullary cord, which unites the fore and lower part of the corpora striata, and which spreads its connections for a full inch and a half into the middle lobe of the brain upon each side. We see it stretched transversely immediately under the anterior crura of the fornix. It is in figure like a bow; its extremities stretching (with a convexity forward) into the middle portion of the brain towards the extremity of the fossa Silvii, where it terminates in the medullary matter of the middle lobe of the brain.

The THALAMI NERVORUM OPTICORUM are hid by the posterior angles of the fornix, and the plexus choroides: we do not see them fully until we have lifted the fornix, and the velum or membrane which stretches under the fornix. They are somewhat of an irregular oval shape; they are whiter than the corpora striata, their surface being chiefly of medullary matter. Internally they are cineritious; and the medullary and cineritious matter is blended in striæ like the anterior tubercles of the ventricles or corpora striata.

The thalami nervorum opticorum, having their convex surface towards each other, unite under the fornix by what is called the COMMISSURA MOLLIS, in opposition to the commissura magna, which is the corpus collosum; the commissura anterior, which unites the fore part of the corpora striata; and the commissura posterior, which is yet to be described.

This soft commissure of the brain, or the union of the optic thalami, is so soft that the slightest force will tear it, or in dissection, the parts being unequally supported, the thalami will be separated and this connection lost.† After such separation of the tubercles, there remains very little appearance of their having been united. Sabbatier, after the

* "*Hæc pars commune sensorium est*, quod sensibilium omnium ictus a nervis cu-"jusque organi dilatos accipit, adeoque *omnis sensionis perceptionem afficit*; cujus-"modi sensibilium ictus, cum hinc ulterius in cerebrum trajiciuntur, *sensioni* statim "imaginatio succedit; atque insuper hæc corpora, uti sensuum omnium impetus ita "motuum localium spontaneorum primos instinctus suscipiunt." Willis, edit. 4. p 43.

† Morgagni and Vicq d'Azyr say they have seen this commissure double.

most careful dissection, says expressly that he could never observe this union; and he conceives, that in the smoothness of the contiguous surfaces he has a proof of there never being such a union; but he goes on to say, "The fruits of my research were, that I constantly found a soft "cord of a cineritious colour, and about a line or a line and a half in di-"ameter, passing betwixt them."

I have seen, when the ventricles were distended in hydrocephalus, and the communication betwixt the three ventricles enlarged to a square cavity of nearly an inch in diameter*, that this union was drawn out to some length, but still was above half an inch in diameter. The commissura mollis is exceedingly soft, of a cineritious colour, and vessels are sometimes seen to cross upon its surface. It seems to be the continuation of the grey or cineritious substance which covers the internal surface of the optic thalami.†

Towards the fore part of the thalami we have to observe a peculiar eminence or convexity, viz. the ANTERIOR TUBERCLES of the optic thalami. In making a horizontal section of the thalami, we find that we cut across a medullary streak or cord which descends from this tubercle to the mamillary processes, or corpora albicantia, in the base of the brain.‡ Its course is deep in the substance of the brain, and somewhat oblique. The limits of the thalami externally are contiguous to the corpus striatum, but betwixt them there intervenes a white medullary tract, which is continuous with the medullary striæ, and which, as it marks the limits of the two great tubercles of the lateral ventricles, takes a course inwards towards the anterior pillars or crura of the fornix and middle of the anterior commissure. The surface of this tract, as seen in the lateral ventricle, is the TENIA SEMICIRCULARIS GEMINUM, which we shall presently more particularly describe.

To understand the further connections and importance of the optic thalami, we must dissect the base of the brain. There we find that it is through the corpora striata, and the thalami nervorum opticorum, that the crura cerebri establish their extensive connection with the internal mass of the brain; particularly we find that the crura shoot up into the back and lower part of the thalami.

Here on the lower part also we may observe the TRACTUS OPTICUS, which we may trace backwards from the optic nerves. They surround the crura cerebri with a semicircular sweep, swelling out at the same time, and terminating in three considerable tuberosities: they are finally confounded with the lower part of the optic thalami§: at the same time there runs up a division into the nates.

The TENIA SEMICIRCULARIS GEMINUM is visible on the upper part of these convexities in prosecuting the dissection from above; it is the

* In quadrupeds the adhesion is more extensive.

† Mais il n'y a point de continuité, proprement dite, entre la substance intime de ces couches et la commissure molle dont il s'agit. Vicq d'Azyr, Planc. de Cerv. p. 23.

‡ See Vicq d'Azyr, plate xii. Mém. de l'Acad. Royale, 1781, p. 528. and plate 2. fig. 5.

§ Willis, seeing the first and second pair of nerves so closely connected with these tubercles, and supposing, as we have mentioned in a former note, that the corpora striata were the common sensorium, concludes, "hinc ratio patet, cur odores sive olfactus "objecta ipsum adeo cerebrum feriunt, et immediatè afficiunt; item cur inter visionem "et imaginationem communicatio citissima habetur." P. 44.

tract of the medullary matter, which is betwixt the two great tubercles of the lateral ventricle, the corpus striatum and thalamus nervi optici. Towards the fore part of this tract its surface is covered with a layer of a semi-transparent greyish matter, through which we see the veins which pass from the surface of the corpora striata to join the vena Galeni.* Sabbatier makes the anterior extremity of this medullary body join the anterior pillar of the fornix. Haller makes it join the anterior commissure; and Vicq d'Azyr says they separate again where they seem to unite forwards and lose themselves on the corpora striata. Their posterior extremities are lost in the hippocampi; they thus form a kind of longitudinal commissure which establishes a communication betwixt the fore and back part of the cerebrum.

OF THE THIRD VENTRICLE.

The third ventricle does not at all answer to the conception we form of the ventricles from the lateral ones. It is a mere sulcus, lying betwixt the thalami nervorum opticorum, and betwixt the crura cerebri, which are continued down from these tubercles. It is a longitudinal slit, rima, or gutter-like cavity, which is made irregular, and is divided by the union of the optic thalami: and, finally, it is canopied by the fornix and vascular velum, which stretches over the thalami.†

The third ventricle opens forward and upwards into the two lateral ventricles, and under the common communication it opens into the infundibulum. Backwards it is continued by a canal which passes under the tubercula quadrigemina, or nates and testes, into the fourth ventricle. The bottom of the third ventricle is closed by a small stratum of cineritious matter, *cloison pulpeuse du troisieme ventricule*; this fills up the space betwixt the junction of the optic nerves and the anterior commissure. We see it when dissecting the base of the brain. Lifting the optic nerves, we shall find it strengthened by the pia mater, and consisting of striæ which pass obliquely backwards and downwards, and some of which, while they adhere to the optic nerves, pass into them.

As we have found that the pia mater could be traced into the lateral ventricles, and as, by tearing with the probe the connections of those membranes, we could penetrate into the lateral ventricle without piercing the substance of the brain, so here we can penetrate into the third ventricle, which is deepest of all, and also into the fourth, without lacerating the substance of the brain. Thus, after raising the vascular membrane of the base, we can pass a probe under the corpus callosum backwards into the third ventricle, and by raising the cerebellum from the medulla oblongata, and separating the adhesions of the pia mater, we get access to the fourth ventricle. We conclude, then, that the ventricles are not formed, as we should at first conceive, in the substance of

* "Quelquefois il se detache du tænia semicircularis entre le corps strié et la couche "optique un silet blanc, qui faisant un angle très aigu, soit en devant soit en arrière, "monte à une certaine hauteur sur le corps cannele." Vicq d'Azyr, Mém. de l'Acad. Royale, 1781, p. 530.

† "Hanc caveam ventriculum tertium vulgo vocant, quæ et ipsa cum plena sint "omnia nihil est nisi contiguorum thalamorum limes." Haller

the brain, but that they are formed by the replication and foldings of the convolutions of the brain.

OF THE INFUNDIBULUM.

As I have explained in my tables of the brain, there is much confusion regarding the terms vulva and anus. Vulva is the space by which the three ventricles communicate, as seen when the fornix is lifted, in prosecuting the dissection from above downwards, viz. betwixt the thalami nervorum opticorum and before the commissura mollis. The anus is behind this commissure, and near the nates and testes ; both these are mentioned as communications betwixt the ventricles ; but we know that the union of the plexus choroides, of the two lateral ventricles, and of the termination of the velum under the anterior part of the fornix, leaves the vulva free. But the velum spreading over the thalami, and under the posterior part of the fornix, covers the anus ; and it appears as a communication similar to the other only when the velum is torn up.

If we pass a probe gently downwards and forwards from the vulva or foramen commune anterius, or communication betwixt the ventricles, we pass it into the infundibulum. The INFUNDIBULUM is a funnel of a soft cineritious matter, which leads from the bottom and fore part of the third ventricle towards the glandula pituitaria, which is seated in the sella turcica of the sphenoid bone.

The infundibulum is formed of cineritious matter, which is continued from the bottom of the third ventricle, and which adheres to the back part of the optic nerves ; or, according to Wharton, of an external membrane with cineritious matter internally. Its cavity becomes contracted before it reaches the glandula pituitaria. Whether it be really capable of conveying the fluids of the ventricles, or whether it be actually pervious, is likely to remain a disputed point. Tarin, and M. Adolphus Murray, and Haller, believe with the oldest writers that it is pervious. Sœmmerring and Vicq d'Azyr have in their experiments found it shut.* But to the opinion that the infundibulum conveyed the superfluous moisture from the ventricles†, it did not seem necessary to Vieussens that we should find it to have a cavity in all its length. He conceived that where the apparent cavity terminated, less visible pores were continued towards the gland.

* "Sed non ad apicem usque pervium." Sœmmerring.

† "Structura, situque infundibuli spectatis, connectionis, et societatis, quam cum cerebro, et glandula pituitaria habet, rationibus æquo judicio perpensis, unicum illius "usum esse, ut aquosum, seu lymphaticum quemdam cerebro depluentum humorem, "majoris, ad instar vasis lymphatici excipiat et pituitariam versus glandulam sensim "transmittat, non autumare non possumus : Etenim eum intertextarum plexibus choroidæis glandularum usus sit, ut sanguinis calvariam subeuntis, spiritusque animalis "materiam suppeditantis, aquosiorem partem, desinentibus in ipsas ab arteriis depositum excipiant, quæ deinceps per insensiles rarissimæ, qua obducuntur, membranæ "poros, sensim transfluit, et partim per vulvam partimve per anum, in tertium cerebri "ventriculum delabitur ; nullus esse videtur ambigendi locus, quin aquosus omnis humore glandulis, quæ plexuum choroidæorum vasis interserunter, sensim affluens, ad "infundibulum deferatur." Vieussens, p. 50. Such was the opinion regarding the economy of the brain ; and now we have no theory, good or bad, nor any explanation of this connection of the gland with the ventricles of the brain, to offer.

INFUNDIBULUM AND PITUITARY GLAND.

What is called the PITUITARY GLAND is a reddish body of a glandular-like structure*, which is seated in the sella Turcica of the sphenoid bone. It is plain upon its upper surface, or rather perhaps a little hollowed, of a globular shape below, and having a division into lobes. The infundibulum terminates in it, piercing the dura mater, a thin lamina of which spreads over the gland. The gland lies surrounded with the circular sinus, and has the cavernous sinus upon the sides; into these last, vessels have been seen to pass from the gland†, which, as Sœmmerring observes, were probably veins. A distinction of substance has been observed in this gland, and it is by some considered as a part of the brain; or, being like the cineritious substance, it has been supposed that it gave nerves to the fifth or sixth pair.

It was conceived that this body, receiving the superfluous moisture of the brain, conveyed it into the nose, or into the neighbouring sinuses.‡ To countenance this opinion, there was no want of cases proving the accumulation of the fluids of the ventricles in consequence of the scirrhus of this gland§, while in truth dissection has shown no connection betwixt the diseases of the ventricles and pituitary gland. M. Littre gave both a vascular structure and muscular fibres to this body, and conceived that its operations brought down the water and air from the ventricles of the brain.‖

THE TUBERCULA QUADRIGEMINA.

The tubercula quadrigemina, or nates and testes, are seen when we continue to lift back the posterior part of the fornix and corpus callosum, and when we have lifted back the velum with the vena Galeni. We find, in doing this, that the velum is connected with the pineal gland, which is seated upon these tubercules.

The tubercula quadrigemina are not in the cavities or ventricles of the brain, but are seen upon lifting and turning forward the posterior lobes of the cerebrum from the cerebellum.

These four tubercules are behind the third ventricle, and above the fourth. As they are immediately in the centre of the brain, they form a kind of commissure, and they both communicate with the tubercles, from which the tractus opticus emerges. The uppermost two are the NATES, the lower are the TESTES; the former are less white than the latter. A little under the inferior tubercle we find a small tract of me-

* It perhaps has only the form of a gland. Haller says, "non acinosa quidem, neque "nullius alterius glandulæ similes, quæ potius cerebri quidam sit appendix." See also Bordeu, Recherch. Anatomiq. sur les Glands. Pituet. Glandulæ Vitium, Sandift. Thes. Vol. III.

† Adolph. Murray de Infundib.

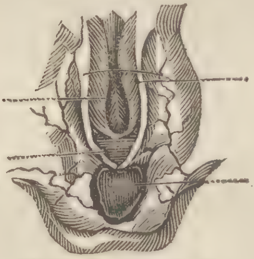
‡ Lower, Tract de Corde.

§ Schneider (de Catar.) first opposed this theory; showed that there was no communication betwixt the brain and the nose, and maintained that no fluid, not even the blood which flowed from the nose, had any connection with the brain; he was supported by other able anatomists. The old opinion was revived by *M. Bouillet, Elémens de Medecine pratique.*

‖ See Littre, Mem. de l'Acad. des Sciences, 1707.

dullary matter, which extends to the thalami nervorum opticorum, and the crura cerebri. And from the lower part of the testes there projects backwards, connecting itself with the crura cerebelli, a thin medullary lamina, which is the VALVULA VIEUSSENII, PROCESSUS A CEREBELLO AD TESTES, OR VELUM INTERJECTUM. Behind the posterior tubercle, or from this medullary lamina itself, the fourth pair of nerves take their origin. Sometimes those four tubercles are of the same size ; sometimes the posterior, sometimes the anterior tubercles, are the larger : a perpendicular section of them shows a mutual communication of striæ of medullary and cineritious matter, but those are seen faintly.

THE PINEAL GLAND.



Tubercula quadrigemina.

The pineal gland is a little glandular-like body, seated above the tubercula quadrigemina, and behind the thalami nervorum opticorum ; it is fixed, says Winslow, like a button. It consists of cineritious matter covered with the pia mater ; its base is surrounded with medullary matter ; it adheres firmly to the velum vasculosum, and is apt to be displaced or torn from its pedunculi in lifting that membrane. It is a small soft greyish body, irregularly round, or of the figure of a pine-apple ; or, of all things, likest the heart of a frog.* Its pedunculi, or footstalks, pass out from a transverse medullary base, which unites it to the posterior commissure. Those pedunculi pass on each side to the thalami nervorum opticorum (leaving a passage under and betwixt them to the fourth ventricle.) Their extremities pass forward upon the internal surface of the thalami nervorum opticorum, and are united to the anterior crura of the fornix.

Vicq d'Azyr remarks, that although the ideas of Galen and Descartes†, and a crowd of others, are remembered only with ridicule, there are still some peculiarities in the situations and connection of this body,

* Ruysch considered the substance of this gland as different from that of the cerebrum or cerebellum, and different, also, from all other glands. [It is entirely ridiculous to call it " a *gland*" at all.] J. D. G.

† Alluding to their opinion of this being the seat of the soul ; Willis imposed upon " this part a lower office, " Ejusque munus non aliud omnino esse quam aliarum " glandularum quæ juxta vasorum sanguiferorum concursus disponuntur : nempe ut " humores serosos a sanguine arterioso depositos, excipiat, et in se retineat ; donec aut " *venæ* depletiores factæ eosdem resorbeant, aut lymphæ ductus (si qui adfuerint) eos " extra convehant." Willis, p. 46.

which mark its importance. It is composed of cineritious substance; it is in fact, a prolongation of the substance of the brain, and by its pedunculi, which are like two nerves, it is connected with the thalami nervorum opticorum, with the fornix, and consequently with the corpus callosum, the hypocampus and corpora albicantia, which are themselves the centre of union to several medullary cords: therefore he concludes that the pineal gland must be an important organ.*

The pineal gland has often in it little peculiar grains and calculi, resembling bone in its constituent parts.† It has a great variety of form and size; sometimes hollow, and there is also a sinus found in it. I have found it surrounded with pus in an idiot boy, who was accustomed to wander about the Leith glass-houses. He died with symptoms of hydrocephalus; and in his ventricles, accordingly, there was found much fluid. Malacarne gives a case of its having degenerated into hydatids, like a cluster of grapes; I have also seen this appearance. In some cases it has not been found upon dissection.

POSTERIOR COMMISSURE.

The base of the pineal gland is connected with the posterior commissure of the brain. This commissure is seen like a cord, or like the anterior commissure, towards the back part of the third ventricle, before the tubercula quadrigemina, and above the iter ad quartum ventriculum. Betwixt this commissure and the base of the pineal gland we have to observe two or three medullary filaments, not passing from the gland, but lying parallel to the commissure. But this part of the brain, which appears like a cord, does not deserve the name of commissure; it does not pass on each side into the substance of the brain, as the anterior one does; it is lost in the neighbouring border of the medullary matter, and is merely this matter reflected, so as to present a rounded edge.

CEREBELLUM.

The cerebellum is one of the grand divisions of the brain. It weighs about a sixth or seventh part of the whole brain; it lodges in that part of the base of the cranium which belongs to the occipital bone, and has the tentorium stretched over it; it is divided into a CENTRAL OF MIDDLE PART, and two great LATERAL PORTIONS OF LOBES.

The central, or middle part, is anterior to the lobes, and betwixt them

* Mém. de l'Acad. Royale, An. 1781, p. 533. See Observ. par M. Meckel sur le Gland pineal, sur la cloison transparente, et sur l'origine du nerf de la septieme paire. L'Acad. Berlin. 1765.

† "La parte anteriore della base n'è ordinari amente midollare, e qui appunto l'ho "moltissime volte veduta gessata, ossosa, tartarosa e friabile, vizi, che ho trovati anche "molte volte nei piccinoli." Malacarne, part ii. p. 81. *Acervulus:* Meckel, Mém. de l'Acad. des Sciences a Berlin, 1755. fig. 1. b. b. Vicq d'Azyr, tab. xxvii. "Super "medullosum conarii vinculum vel in ipso vinculo, vel in ipso denique acervulo, plerumque vero ante acervulum iam in fetibus inmaturis peculiares quidam lapilli, mox "maiorum acervulum, mox vero duo vel tres minores acervulos constituentes, helui, "semiperlucidi, iunioribus semper pallidiores, annosioribus fusciores, infantibus ob "coloris languorem et perlucidatem difficiles cognitu siccati albidiores et opaciores in"veniuntur." Sœmmerring, p. 63.

and the cerebrum: this is the part very commonly called, from its appearance, the VERMIFORM PROCESS; and upon the sides we have two portions, sometimes called lateral vermiform processes. The term process here is certainly improper; for it implies that those parts are extended from the lobes; whereas the PROCESSUS VERMIFORMIS is the part we see in all creatures which have a spinal marrow; while the lateral lobes or hemispheres are the superadded parts, and bestowed upon the higher animals.

The cineritious matter of the cerebellum is external, like that of the great mass of the cerebrum: but the medullary internal matter presents an appearance somewhat different; for on a section being made, it appears branching like a tree, and has been called *arbor vitæ.*

The concentration of the medullary matter, from the two sides of the cerebellum, towards the nodus cerebri, forms what are called the crura cerebelli. One portion of this medullary matter forms the pons or nodus, and constitutes the commissure uniting the lateral divisions of the cerebellum; the other division of the *crus* is the *corpus restiforme*, which runs into the medulla oblongata.

In dividing these crura we find in each of them the stain of yellowish matter, which is called CORPUS RHOMBOIDEUM, or CORPUS DENTATUM.

OF THE FOURTH VENTRICLE.

The fourth ventricle is the ventricle of the cerebellum; it descends perpendicularly before the cerebellum: it is inclosed on the upper part by the valvula Vieussenii; on the sides by the crura cerebelli; behind, by the pars media; below, by the medulla spinalis, and is enclosed there by the pia mater.

When, from the third ventricle, we pass our probe obliquely backwards and downwards under the posterior commissure, it passes into the ITER AD QUARTUM VENTRICULUM, or AQUEDUCT of SILVIUS. This passage to the fourth ventricle goes before the tubercula quadrigemina. The VALVULA VIEUSSENII, it was supposed, prevented the falling down of the moisture of the other cavities into the fourth ventricle*: it is more properly called the PROCESSUS CEREBELLI AD TESTES, being a medullary lamina spread over the ventricle, and betwixt the crura cerebelli, as they rise from the internal medullary part of the cerebellum.

From the aqueduct there is continued down upon the fore part of the fourth ventricle a kind of fissure, which Vesalius, conceiving it to have some resemblance to a writing quill, called CALAMUS SCRIPTORIUS. The same fissure or furrow is continued down some way upon the spinal marrow.

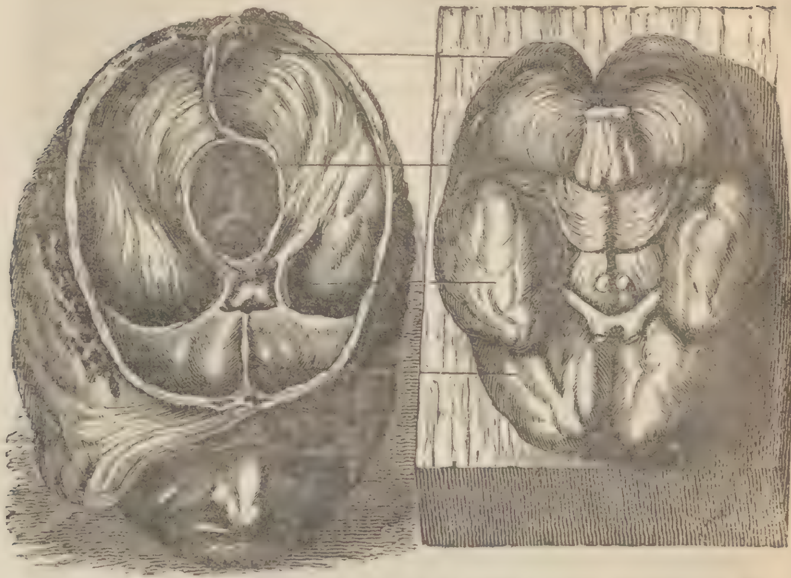
There pass up obliquely outwards, on each side of the calamus scriptorius, medullary lines, three or four in number, but sometimes seven are observed.†

In the fourth ventricle, as in the others, are some convolutions of the plexus choroides; these are on each side at the termination of the vermis; they are continued out upon the base of the brain, and are seen exposed betwixt the seventh and eighth pair of nerves.

* Alveus Silvii.

† Haller, Physiol. tom. iv. p. 78.

OF THE BASE OF THE BRAIN AND ORIGIN OF THE NERVES.



We have anticipated much that might have fallen to be treated of in this division of our subject; but my intention here is to give a connected view of the parts, as seen when we have raised the brain from the skull, and when, having the base presented to us, we are about to enumerate the origins of the nerves.

The first appearance which strikes us, is the great proportion of the medullary matter in the base of the brain: the whole surface of the brain seen from above, was cineritious; but below, the centrical medullary part of the brain is seen emerging from the covering of the cineritious matter, and gathering together from the several internal medullary processes of the brain. Those great medullary prolongations of the cerebrum and cerebellum are the crura, and from them the principal nerves arise.

Shall we here yield to the fascination of new doctrines, and derange the demonstration according to the method of Dr. Spurzheim? For the whole question amounts to this: shall we describe these crura of the cerebellum coming down from the brain, or going up and expanding into it? It is obvious, I think, that these are only modes of speaking; for we have no authority in nature for following the nerves, and processes of nervous matter, in one direction, more than another.* If, there-

* We cannot avoid attributing this observation to the force of the author's prejudice. The best of all reasons can be given for studying the brain and nerves as Spurzheim does, because it is according to the mode in which the formation of these parts originally takes place. J. D. G.

fore, I continue to say, that the crus cerebri "comes down," I mean only that from the internal parts of the brain, which, from previous description, my reader may be supposed to know is connected or continuous with the part I am now describing.

The CRURA CEREBRI are composed of a white fibrous medullary matter, in which also there is a mixture of cineritious substance. They are formed from the whole central medullary part of the cerebrum; or more immediately from the inferior and lateral part of the corpora striata, and from the superior and internal part of the thalami nervorum opticorum; and from the conflux of medullary matter from the anterior and posterior lobes of the cerebrum. They are, in short, formed by the converging striæ of the cerebrum. From all these various parts the medullary matter may be traced downwards and backwards, and concentrating into a smaller space, to form the crura. The crura, contracting their diameters, unite together at an acute angle, and are united to the pons Varolii, or nodus cerebri; they pass on, under the pons Varolii, to form the anterior columns of the medulla oblongata; and, as they unite with it, they raise it into the eminences, called CORPORA PYRAMIDALIA. In those processes of the cerebrum the cineritious and medullary substances mingle with some degree of confusion; so that when we make a section of the crura cerebri near to their union with the pons Varolii, we observe a substance of a dark-brown colour, the *locus niger crurum cerebri* of Vicq d'Azyr.

Behind the union of the optic nerves, and nearer these crura, we perceive two white bodies, called the CORPORA ALBICANTIA. Anterior to these is the *infundibulum*.—The *tuber cinerius*. In the angle of the union of the crura cerebri, behind the corpora albicantia, and before the protuberance of the pons Varolii, we observe a matter less perfectly white than the surrounding medullary substance, which forms a floor to the third ventricle. This part is perforated with a great many holes, for the transmission of blood-vessels, and is the *substance perforée* of Vicq d'Azyr.*

CRURA CEREBELLI.

The crura cerebelli are more exposed than those of the cerebrum. A medullary mass is seen to come out of the lateral portion of the cerebellum, and join itself to the posterior part of the medulla oblongata. This has been called CORPUS RESTIFORME, or PROCESSUS CEREBELLI AD MEDULLAM OBLONGATAM. That is, they have described this portion like a cord of connection, or like a prolongation of the cerebellum, to which, as a mode of expression, I say again, there is as little rational objection as to the mode of Spurzheim. It is, I believe, quite impossible to avoid the language of metaphor here. If I use the words divide or split, I am tracing, as it were, in a course for which, I again acknowledge, I have no authority in the thing itself. These crura, then, are formed by the union of the internal medullary part of the cerebellum, or

* Vicq d'Azyr makes three divisions of this *substance perforée*—1st. At the roots of the tubercles, from whence the first pair of nerves emerge betwixt the roots of those nerves, and near the origin of the optic nerves. 2d. Those I mention betwixt the crura cerebri. 3d. On the outer contour of the optic thalami.

the arbor vitæ, and also by a medullary prolongation from the PROCESSUS VERMIFORMIS. They are composed of medullary matter, except near the pons Varolii, where we observe a mixture of coloured striæ: and on dividing one of the crura longitudinally, as it comes out of the cerebellum, we find a mass of cineritious coloured matter. This is the CORPUS DENTATUM, or RHOMBOIDEUM, of authors.*

PONS VAROLII.

The PONS VAROLII, TUBER ANNULARE, or NODUS CEREBRI, is formed by the union of the crura cerebri and cerebelli; those names are almost descriptive of its shape and relation to the other parts. Varolius, looking upon those parts inverted, compares the crura cerebri to a river passing under a bridge, and thence named it Pons. The nodus cerebri, again, is a name well applied; since this medullary eminence has much the appearance of a knot cast upon the medullary processes of the cerebrum.

On the surface of this medullary protuberance there are many transverse fibres, which, uniting in the middle, form a kind of raphe, which, upon a superficial section, shows a longitudinal medullary line. The fibres upon the surface of this body are uniform and parallel to each other in the most projecting part; but upon the sides, they disperse to give place to the fifth pair of nerves.†

A deep incision of the pons Varolii, while it shows the union of the crura cerebri, cerebelli, and pons Varolii, also shows the white medullary tracts which extend from the crura cerebri, through the pons Varolii, to the corpora pyramidalia; a little higher up, part of these striæ pass through the LOCUS NIGER CRURUM CEREBRI. We see also the transverse fibres of the medullary and cineritious substance, which make a right angle with those longitudinal tracts. On the whole, though the pons Varolii differs in form and place from the commissura magna cerebri, yet I am of opinion that it stands in the same relation to the lateral portions of the cerebellum that the corpus callosum does to the cerebrum; that it is the great commissure of the cerebellum, uniting its lateral parts, and associating the two organs.

Anatomists have sought to explain a very curious phenomenon, by supposing that there is a decussation of the nervous filaments in the nodus or pons. It has often happened that an injury to the one side of the brain, an ulcer or tumour on one side, caused a loss of power in the opposite side of the body,‡ and the latest authority we have§ proves that a tumour on the one side of the pons Varolii will produce an effect on the other side of the body. But no decussation can be observed; fibres,

* Sive serratum of Vieussens: Le corps festonné ou dentelé of Vicq d'Azyr.

† Some have divided the surface of the pons Varolii into three divisions or bands: 1. The superior band, which winds round to embrace the crura cerebri: 2. The middle band, and 3d. the inferior band, the fibres of which intermingle with those of the crura cerebelli. They likewise subdivide the crura cerebelli; and that part which we have called corpus restiforme, has been named *pedoncule inferieure* of the crura cerebelli.

‡ The observation has descended from *Hippocrates*, and the explanation that it depends on a decussation of the roots of the nerves is from *Aretæus*.

§ Medico-Chirur. Transactions, VII.

as I have said, run across like commissures, but the tract of matter is direct and parallel, not oblique.

I am tempted to think there must remain much obscurity on this subject of the decussation of the fibres of the brain, or origin of nerves. I have found that the effect is not constant. An ulcer in the hemisphere of the cerebrum produced weakness in the same side; and in one well marked case of hydrocephalus, when the brain on dissection was equally affected on both sides, the one side of the body was convulsed and drawn up, and the other side motionless. This is not a singular occurrence; I have seen the eyes, face, and tongue in perpetual motion; but the action entirely on one side, the paralysis on the other, while both lateral ventricles were full of water, and the disorder of the brain, as seen on dissection, equally affecting both sides of the organ.

MEDULLA OBLONGATA.

The medulla oblongata is the prolongation of the substance of the crura cerebri and cerebelli from the pons Varolii; it is consequently the continuation of the encephalon, which, after giving off the nerves that pass through the foramina of the skull, enters the canal of the spine to supply the spinal nerves. The medulla oblongata is marked at its upper end by a deep sulcus dividing it from the pons Varolii; but towards the spinal cavity it decreases in thickness, and there is no natural distinction or sulcus to mark the point where the medulla oblongata ends, and the medulla spinalis begins; nor perhaps is the medulla oblongata to be considered in any other light than as the beginning of the spinal marrow. When it passes the foramen magnum, it ceases to be called the medulla oblongata, and is more properly medulla spinalis.

We have to observe certain eminences upon the fore part of the medulla oblongata, viz. two corpora pyramidalia, and two corpora olivaria. The CORPORA PYRAMIDALIA, so called from their shape, are those in the middle. There is formed betwixt them and the pons Varolii (being three tubercles placed together) a little sulcus, which some have called the FORAMEN CÆCUM. Betwixt these eminences called pyramidalia there is a longitudinal fissure, in the bottom of which there may be observed transverse little cords, which are like commissures connecting the two sides of the medulla oblongata; and the corpora pyramidalia, which are prolonged downwards, twist, and form a decussation.

The CORPORA OLIVARIA lie upon the outside of the corpora pyramidalia. They are distinct oval convexities rising from the fore and lateral parts of the medulla oblongata. They are of a very peculiar structure, for anatomists had observed a mixture of a yellow or cineritious-coloured matter in them; but Vicq d'Azyr has described a regular oval medullary substance, or body surrounded with cineritious-coloured matter, like a miniature representation of the cerebrum itself; he calls it CORPUS DENTATUM EMINENTIÆ OLIVARIS.

The CORPORA RESTIFORMIA are the projections or cords behind the corpora olivaria, which come down from the crura cerebelli. (Betwixt this column of nervous substance and the corpus olivare there is a cord or column which gives origin to the nerves of respiration.) The corpus restiforme, as it is called, if by that is meant the posterior portion of ner-

vous matter which goes down from the cerebellum to the medulla spinalis, is double, or forms two columns distinct on the posterior surface of the medulla oblongata.

MEDULLA SPINALIS.

The medulla spinalis is certainly, in part at least, an elongation of the brain. Its name implies its situation, that it is contained within the tube of the spine. Though chiefly composed of medullary matter, it is not entirely so; for there is an irregular, central, cineritious substance through its whole extent, having something of a crucial form when a section is made of it.* There are continued down from the calamus scriptorius behind, and the rima, formed by the corpora pyramidalia, before, two fissures which divide the spinal marrow into lateral portions. On the back part, however, the fissure is less distinguishable. Into the anterior one the little vessels penetrate to supply the cineritious matter with blood. The two lateral portions are divided into an anterior and posterior portion, so that this prolongation has four distinct portions very distinctly seen; but that there are other columns of different functions in the composition of the spinal marrow, I have given reasons to believe in the introduction.

The tube of the vertebræ is connected by a strong ligamentous sheath, which runs down the whole length within the tube. The dura mater, after lining the internal surface of the cranium, goes out by the great foramen, and forms a kind of funnel; at the occipital foramen it is united firmly to the ligaments. Further down, however, it forms a separate tube. The tunica arachnoidea again adheres loosely to the medullary matter of the spinal marrow, having a kind of secretion within it, while the pia mater closely embraces and is intimately united to it.

Through the whole length of the spinal marrow the arachnoid membrane forms a ligamentous connection betwixt the medullary matter and the sheath or theca. A firm slip passes betwixt the roots of the nerves, and being tucked in the form of acute processes at distinct intervals to the sheath, it assumes the form of the teeth of a saw. It is from this pointed appearance that it is called the Ligamentum Denticulatum, or Dentatum.

Laying aside authorities, and only contemplating the dissection of the medulla oblongata and medulla spinalis, I would describe them as a great column continued from the brain, and lying embraced and protected by a sort of continued skull, the spinal tube. This column consists of lesser columns, so that it resembles a Gothic pillar. These different columns, as I have already expressed my opinion, are distinct organs, and give rise to nerves, which are possessed of powers which correspond with the origin or connection of their roots.

* The surface of the spinal marrow has also been observed to be of a darker colour, and in large animals cineritious. (Dr. Monro's Nervous System.)

SUPPLEMENTARY OBSERVATIONS ON THE DEVELOPEMENT OF THE CENTRAL PARTS OF THE NERVOUS SYSTEM.

[From Meckel.]

[The volume of the central portion of the nervous system is generally greater in proportion to that of the body, according to the youth of the organism. Until the third month of pregnancy, the spinal marrow occupies the whole length of the vertebral canal. It is true, that from this period it begins to gather up, but it is not until the eighth month of intra-uterine life, that it assumes the proportions which are subsequently preserved. It is also thicker during the first periods of life than it is afterwards.

The encephalon, excepting the cerebellum, has also a proportionably greater extent. However it must not be thought, especially in relation to this viscus, that *greater extent* is perfectly synonymous with more *voluminous mass*; because the parietes of the brain are proportionally thinner than they are at a more advanced age. Until the period of full developement, the encephalon continues to be larger in proportion to the body than it is afterwards; for between six and seven years, according to Wenzel, and even after the third year according to Sœmmerring, it has already acquired the volume and weight it is to preserve during the rest of life. The very imperfect developement of the posterior part of the vertebral column leaves the spinal marrow and encephalon much more free and disengaged during the first periods of existence.

The caliber of the spinal marrow is the more uniform according to the youth of the embryon. The enlargements corresponding to the nerves of the extremities are only developed in proportion as the extremities themselves are formed.

The spinal marrow, which is entirely solid not only in adult subjects, but from a few months after birth, has at first a canal extending through its whole length, which is continuous with the cerebral fissure, and is largest in those places where the spinal cord is enlarged.

This canal is not round at first, but elongated from before backwards, and with the exception of the thin lamellæ bounding it anteriorly, traverses the entire thickness of the spinal marrow. It thence results that the internal and external surfaces of the spinal marrow are continuous originally, that the whole canal is much larger during the first periods of life than at a more advanced age, and that then it is less like a canal, properly speaking, than a fissure which separates almost totally the two lateral halves of the spinal cord. By degrees this canal is closed and contracts at the posterior part from without inwards. Subsequently, the spinal marrow is folded longitudinally as much before as behind; hence arise the anterior and posterior longitudinal grooves, which never communicate with the central canal, as the brain and even the summit of the spinal cord have during life, not only two longitudinal fissures, one superior and the other inferior, but also central cavities, which are separated from these fissures by medullary matter throughout a great part of their extent at least, and by the pia mater throughout their whole course. However, the longitudinal grooves of the spinal marrow

are larger during the first periods of life, and it is not uncommon for the posterior to disappear entirely as the subject advances in years.

Although the spinal marrow is at first very much larger in proportion to the whole body than it is in the adult, nevertheless, we readily perceive an inverse ratio to be established between it and the encephalon, both on account of the developement acquired by the latter, and the diminution of the spinal cord. Thus I have found that the proportion of the spinal marrow to the brain was still as 1 to 107, and even 1 to 112 in the fœtus at birth and a child of five months; for the brain of the fœtus weighed nine ounces and four drachms, that of the child of five months 21 ounces; the spinal marrow of the fœtus weighed two scruples, five grains, that of the child a drachm and a half. On the contrary, in a fœtus of five months the proportion was as 1 to 63, since the brain weighed six drachms one scruple and eight grains, and the spinal marrow six grains. It was as 1 to 18 in a fœtus of three months whose brain weighed thirty-six grains and the spinal marrow two. In the adult it is as 1 to 40.

These calculations will serve to rectify the estimates which some anatomists have given of the difference observed at different periods of life in the respective proportions of the spinal marrow and encephalic mass.

The younger the embryon is, the larger is the spinal marrow in proportion to the encephalic mass. It is manifestly more voluminous and weighty in proportion to the latter even in the human embryon of three months, both on account of its more considerable size and the smallness of the encephalon; but the latter soon transcends it more than in the adult, both because it increases very much, and because the spinal marrow itself diminishes.

The younger the embryon is, the more distinct is the medulla oblongata from the medulla spinalis, and the open angle between them is more of a right angle. The medulla oblongata is proportionally more developed during the early periods of life, than at a more advanced age; this may especially be stated of its inferior and anterior part, which concurs in the formation of the brain. The medulla oblongata is still more distinct in the fœtus at full time and in the young infant than in the adult, and all its parts, principally the eminences on its inferior surface, the pyramidal and olivary bodies, are more salient at the same time and separated by more precise limits. This circumstance seems in direct relation with the more considerable developement of the brain.

The *calamus scriptorius* is much larger in the first periods of existence, because its parietes are thinner, and there is greater distance between them from behind forward. The transverse cord which closes it superiorly, does not exist in the beginning, but it is much more considerable during the latter part of intra-uterine life, than in the adult. The white lines which are seen on the floor of the calamus, do not become apparent until some months after birth; while the grey eminences, situated in front of them, are visible in a fœtus of three months old.

The olivary bodies are perceptible from the third month of uterine life; but at the time the fœtus is matured they are only externally formed of cineritious substance. At the third and even at the fifth month of pregnancy, a small ramified cavity may be discovered within them, which

altogether disappears by the sixth month. After they become solid the cineritious substance at first ramifies in them in a more simple manner than it does at subsequent periods.

The pyramidal bodies are obvious much sooner than the olivary, and are equally in proportion larger in the early state than in the adult.

The annular protuberance, or pons Varolii, does not appear until the third month. It is at first thin and short; its proportional volume to the spinal bulb is still less considerable. The longitudinal groove of the inferior surface is shallower in the full-formed fœtus than in the adult.

The cerebellum is developed sooner than the brain in respect to its composition. Depressions are already visible on the middle of its surface towards the end of the fourth month of uterine life; thus the most considerable depressions, which divide the organ into lobes, appear before the small ones, and they are more superficial and simple at first than they are subsequently.

Notwithstanding all the researches hitherto made, the manner in which the central mass of the nervous system is formed has not yet been perfectly demonstrated. Two characters which it offers at all times of life are especially developed during the early periods, the ventricles, and the distinction into two corresponding lateral portions. We may then conjecture that the central portion of the nervous system is formed in the midst of a fluid, and at its expense; that it assumes the figure of a hollow canal; or that it is developed by plates or cords more or less separated by a median line, where they reunite to form a cavity. According to the latter hypothesis, the number of degrees of developement which the spinal marrow and brain undergo are greater than in the first, which does not admit the primitive form of simple plates. But there are actually facts which support this view, and although it renders the formation of the central mass of the nervous system more complicated, they must not be set aside for the sake of admiring at all hazards the simplicity of the operations of nature. The facts alluded to are the almost total division of the spinal marrow into two lateral portions; the possibility of separating entirely the anterior cords from each other, and thus to change the spinal marrow into two lateral cords; the considerable breadth and thinness of the medulla oblongata; and finally the total separation of the two lateral halves of the cerebellum; probably also of the quadrigeminal tubercles, and very certainly of the optic thalami.

Thus, the central mass of the nervous system is developed from below upwards, without its being determinable whether it is effected by two plates or a single one; these plates growing from before backward, are curved inwards to meet each other, and blend together at the median line, giving origin in this manner to a semi-canal, and afterwards of a complete canal. This theory is supported not only by the facts which are furnished by the history of the embryon, but also by the developement of the nervous system in the series of animals. The dorsal medulla and brain of worms and insects correspond sensibly to the inferior or anterior cords of the same parts in the superior classes of animals, and we may without much difficulty carry these organs to a much higher degree of organization; on one hand by mentally adding the su-

perior cords, and on the other by supposing them united together posteriorly; conditions sufficient to convert the plates or cords which first exist into a canal.

The ulterior developement of the central portion of the nervous system is produced by the growth of the mass which augments the thickness of the walls of the ventricles, and contracts the latter themselves. A period then arrives at which the mass, which was originally smooth and even, becomes very unequal, and acquires at the same time a much greater extent. Still later, differences are established in the nervous substance, which is divided into grey and white, a phenomenon which terminates the developement of the intimate structure. In general these different characters are pronounced in parts, according to their order of appearance. The spinal marrow is the part which first arrives at perfection in all respects. The quadrigeminal tubercles change little after birth. The cerebellum seems to be an exception to the rule, because, although formed later, it arrives at perfection in respect to configuration and texture a long time before the brain, and even before the annular protuberance.*]

SCHEME AND GENERAL DESCRIPTION OF THE ORIGIN OF THE NERVES OF THE ENCEPHALON AND SPINE.

In enumerating the nerves which pass from the cranium, I must now keep to the old way of Willis, counting only nine nerves of the encephalon; because this is a natural method, and can never be entirely exploded. When we open the cranium and look to the nerves, we see them coming off, and taking their course, exactly as Willis described them. His enumeration serves the purposes of dissection, therefore I shall first present them according to his arrangement, only reminding my reader, that nerves of very distinct offices are, in this arrangement, bound together, and take their course through the same foramina.

From the olfactory nerve to that which passes out betwixt the cranium and first vertebra, there are nine nerves.

1st pair.—Olfactory nerves.	*Carunculæ mamillares Math.* de Grad. *Processus ad nares.* Gonth d'Andernac. 8^{um} par Spigel. 1st pair of Willis.
2d pair.—Optic nerves.	*Nervus visivus seu visorius.* Carpi. 1^{m} *par antiquorum.* 2d pair of Willis.
3d pair.—Motores oculorum.	2^{um} par Fallop. et Vesal. Nerfs moteurs communs des yeux. Winslow. 3d pair of Willis.
4th pair.—Trochleares.	*Minor propago* 3^{ii} *Paris, id est* 5^{i} *recentiorum, Fallop.* *Gracilior radix* 3^{ii} *Paris, id est* 5^{i} *recentiorum.* Vesal. *Nervus qui prope nates oritur.*—Eustach. 9^{um} par Cortes: et Columb. 4th pair; or, pathetic nerves of Willis.

* For the observations of Tiedemann, Spurzheim, &c.. See Appendix. A.

5th pair.—Trigemini. Symmetrical nerve of the head, answering to the spinal nerves.		*Nervus anonymus trigeminus multorum.* 3^{um} par Fallop, et Vesal. 5th pair of Willis. Trijumeaux of Winslow.
6th pair.—Abductores.		4^{um} par Fallop. *Radix gracilior* 5^{i} *Paris, id est* 7^{i} *recentiorum Vesal.* *Par oculis prospiciens.* 8^{um} par Casp. Bauhini. 6th pair of Willis. Nerfs oculo-musculaires, ou moteurs externes de Winslow.
7th pair.	Auditory nerves.	2^{um} par Alexand. Benedict. 4^{um} par Carol. Stephan. 5^{um} par Vesal. et aliorum. 6^{um} par V. Horne. Portia mollis, of the Moderns.
	Nervus communicans faciei. Muscular, or motor nerve of the face. Respiratory nerve of the face.	*Distinctus a molli nervus.* Fallop. *Portio ut praecedens* 5^{i} *Paris, id est* 7^{i} *recentiorum.* Vesal. Portio dura, of the Moderns. Le petit sympathique, of Winslow. Facial nerve.
8th pair. Grand respiratory nerve.	Glosso-pharyngeus.	*Qui ad musculos linguæ et faucium tendet.* Fallop. Le rameau lingual de la 8^{e} paire of Winslow. 8th pair d'Andersch. Superior fasciculus of the 8th pair of Willis. *Glosso-Pharyngeus.* Haller.
	Par Vagum.	*Nervus sextus* Galeni *et aliorum.* 5^{a} *conjugatio* Carol. Stephen. 7^{um} par Alex. Benedict. 6^{um} par Casp. Bauhini. 9^{um} par Bidloo. et Andersch. 8th pair of Willis. Le moyen sympathique, of Winslow.
	Spinal accessory nerve.	The spinal nerve.
9th pair.—Lingual.		7^{um} par Fallop. Vesal. *et aliorum.* 11^{um} par Bidloo. 10^{um} par Andersch. *Par linguale medium, vel nervus lingualis medius.*—Haller. Sœmmerring *et aliorum.* The hypoglossal *sub-lingual,* or gustatory. The 9th pair of Willis.
10th pair.—Symmetrical and 1st spinal nerve. Sub-occipital nerve.		10th pair of Willis. 1st spinal, or cervical nerve of Haller. I count this the first cervical nerve.

FIRST PAIR; OR, OLFACTORY NERVES.

The olfactory nerve is soft and pulpy, and soon resolved by putrefaction; therefore, we should not be surprised that it was neglected by the ancients.* It adheres firmly to the lower surface of the anterior lobe of

* The olfactory nerve is in brutes a large prolongation of the substance of the brain, and is the proper mamillary processes. Their olfactory nerves have a cavity or ventricle in them, and it was natural for the ancients to imagine that the pituita of the brain was from this strained through the cribriform plate into the nose. Vesalius proved the absurdity of this opinion; it was, however, revived by Dulaurens. But Willis is not much better, when he describes the proper use of these nerves. He supposed the cri-

the brain, but it does not take its origin here. It is of a triangular shape, as if moulded to the sulcus in which it lies; by being sometimes sunk into the sulcus more or less on one side than the other, it has the appearance of being larger on one side than the other. It takes its origin by three medullary tracts.* 1st, From the corpus striatum; 2d, From the medullary matter of the anterior lobe; 3d, From the fore and under part of the corpus callosum.† When a section is made of it, we observe in it a cineritious portion.

Towards the fore part, this nerve expands into a bulbous oval lobe, which consists of a semi-transparent cineritious substance. This lies upon the cribriform plate, and from it are sent down the nerves which expand upon the membrane of the nose, and compose the organ of smelling.‡

SECOND PAIR; OR, OPTIC NERVES.§

The optic nerves arise from the posterior part of the optic thalami, and from the tubercula quadrigemina or nates. When we trace the optic nerves backwards into the tractus opticus, we find them adhering to the *tuber* cinerius, or layer of grey matter, then taking a circle round the crura cerebri, then enlarging, each forms a tubercle towards the back part of the thalamus opticus, and afterwards unites with the posterior tubercle of the thalamus opticus; at the same time a division stretches further backwards to the testes, while betwixt the posterior tubercle of the thalamus opticus and the nates there is also a communication. When those tubercles are fairly exposed, by separating the middle lobes of the brain, and dissecting away the tunica arachnoides and pia mater, they are seen smooth, and formed of medullary matter; which is uniformly continued from the one to the other, following their gentle convexities with an uninterrupted surface. Within those tubercles is a mixture of cineritious and medullary matter, and especially there is a distinct streak which passes from the tractus opticus to the nates.‖

Tracing the optic nerves from their origin in the brain towards their exit from the skull, we find them approaching gradually, and uniting just before the corpora albicantia and the infundibulum.

Since the days of Galen, it has been a disputed point, whether there is a union simply of the nerves or a decussation. Fishes have the nerve arising from one side of the brain passing to the eye of the other side:

briform plate of the æthmoid bone to prevent bodies from passing up into the brain ("ne quid asperi aut molesti cum illis una ad cerebrum feratur"); while the lymph in those nerves corrected the too pungent odours; "odorum species demulcere, easque "sensorio quadantenus præparare."

* Or we say that the external root generally splits, having two fasciculi. See Prochaska, tab. 1. Scarpa Annot. Anat. p. 106.

† Vicq d'Azyr, M. de l'Acad. Roy. 1781.—"Breviores fibræ medullares cum longi-"oribus exterioribus connexæ nonnunquam cineream particulam excipiunt." Sœmmerring.

‡ Duverney has shewn us, that those nerves passing through the cribriform plate become firm nerves, like those in the other parts of the body. They are to be seen by tearing the membrane of the nose from the bone.

§ The optic nerves were the first pair of Galen and many of the older anatomists, they being ignorant of the olfactory nerves.

‖ Santorini tab. Scarpa Anatom. Annotat. p. 106.

they cross, but they do not unite. Birds have but one optic nerve arising from the brain, which splits and forms the right and left optic nerves. Vesalius dissected a young man at Padua, who had lost his eye a year before: at the same time he dissected a woman, whose eye had been lost a long while. In the latter he found the nerve of that side smaller, firmer, and of a reddish colour, through all its extent. In the young man he observed no effect upon the nerve. He also gives a plate descriptive of an instance in which he found the optic nerves pass on to the eyes of the same side from which they take their origin, without adhering at all.

Valverda, a physician of Spain, who travelled into Italy, and studied the works of Vesalius and human dissection, says, that at Venice he had frequent opportunities of assuring himself that there was no decussation; for robbers were punished for the first offence by losing one of their eyes, and for the second by death. Riolanus, Rolefinkius, and Santorini give observations of the nerve of the injured eye being small and shrivelled, and of their having traced them past their union to the same side of the brain with the eye to which they belonged. Vicq d'Azyr, who, of all authors, I conceive to be the best authority upon such subjects, is decidedly of opinion that there is no decussation. Zinn also agrees with the opinion of Galen, that there is an adhesion and intimate union of substance, but no crossing of the nerves. Sœmmerring deems it sufficient to point out the authorities on both sides of the question, while he has no decided opinion whether there be a perfect decussation or not.* Porterfield, while he allows the intimate union of the optic nerves, has several observations, proving that they have no intersection or decussation.

Sabbatier, encouraged by the authority of Morgagni, says, that he could trace the affection of the nerve of the injured eye no farther than to the union. He discredits the accounts of their having been traced to the same side of the brain, and believes the assertions to be the consequence of previous opinion and prejudice.—There are certain observations of Valsalva, Cheselden, and Petit, which seem to prove, that where the brain is injured, it is the eye of the opposite side that is affected. After their union the optic nerves are much contracted in diameter; still the optic nerve is the largest of the head excepting the fifth pair. It is the firmest of all the nerves of the senses, but softer than the other nerves.†

What remains to be said of the optic nerves, falls more naturally to be treated of when speaking of the organ of vision.

THIRD PAIR OF NERVES; MOTORES OCULORUM.

The third pair of nerves arise from the internal margin of the crura cerebri, and the perforated medullary matter which is betwixt the crura. The delicate filaments of this nerve cannot be traced far into the substance of the brain; but still we may observe them spreading their filaments, and traversing the dark-coloured spot which we have already mentioned to be

* "Ergo utrum omnes nervorum fibræ, an quædam tantum, mutuo se secent, certe "statui nequit."

† Sœmmerring.

visible in the crura cerebri. Some anatomists have said, that the third pair of nerves had an origin also from the nates and testes. Ridley describes them as rising from the pons Varolii.* Malacarne describes an accessary filament to this third pair from the crura cerebelli.†

In relation to the arteries, those nerves are betwixt the posterior artery of the cerebrum, arising from the division of the basilar artery and the anterior artery of the cerebellum.‡ They diverge from each other as they proceed forwards, and each penetrates under the anterior point of the tentorium by the side of the cavernous sinus, and passes through the foramen lacerum. In the general description it is sufficient to say, that they are distributed in common to all the muscles of the eye.

THE FOURTH PAIR OF NERVES.

The fourth pair of nerves, pathetici, or trochleares, are the smallest nerves of the encephalon, being not much larger than a sewing thread. This nerve comes out from betwixt the cerebrum and cerebellum, passes by the side of the pons Varolii, and after a long course pierces the dura mater behind the clynoid process, runs along for some way in a canal or sheath, formed by the dura mater; it then passes above the cavernous sinus, continues its course onwards through the foramen lacerum to the orbit, and is finally appropriated to the superior oblique muscle of the eye.

The origin of the fourth pair, if we take the descriptions of authors, seems to have a much greater variety than any of the other nerves; so that it is common to say, the fourth pair of nerves arises about the region of the nates and testes.§ It is affirmed, that the trochlearis arises sometimes by two filaments, but more commonly by one undivided root.|| This root, according to Vicq d'Azyr, is seen to emerge from a point betwixt the medullary lamina of the cerebellum, or valvula Vieussenii, and the lower part of the tubercula quadrigemina.¶ My opinion is, as I have elsewhere expressed, that it comes from the upper part of the spinal mar-

* They seem to come from the angle betwixt the crura cerebri and pons Varolii. They are flat near the origin, but become round and firm.

† See Desmoulins, Anatomie des Systèmes Nerveux des Animaux à Vertèbres. Atlas, pl. xiii. fig. 1. and 3. z.

‡ "Cette disposition peut expliquer pourquoi on éprouve tant de pésanteur aux yeux "aux approches du sommeil, dans l'ivresse et dans certains espèces de fièvre." Sabbatier. This is a mechanical and a most improbable way of accounting for such an effect.

§ "Pone corpora bigemina posteriora, mox paulo superius, mox paulo inferius, mox "magis exteriora, mox magis interiora versus, radice simplici, duplici, triplici, quin et "quadruplici oritur.—Nonnunquam origo ejus in cerebri valvula, nonnunquam in ipso "frenulo patet, ut humore ventriculi quarti alluatur." Sœmmerring, vol. iv. p. 209.

|| Santorini says they have three roots or little fasciculi. Wrisberg, following Vieussens, says the fourth pair arises from the valvula cerebri. Vicq d'Azyr. See Haller, fas. vii. tab. 3. "Origo alius simplex est, alius duplex; quando simplex est, a processu "a cerebello ad testes exterius prodit, quam est transversa stria, quæ eos processus con-"jungit." Haller, Phys. vol. iv. p. 208.

¶ "Et souvent ils se confondent avec un tractus medullaire placé transversalement "au-dessus de la valvule du cerveau." Vicq d'Azyr. This nerve, says he, cannot be followed into the anterior part of the brain, from its extreme delicacy, and because it is formed from the medullary substance itself, without the admixture of filaments to give it strength. He quotes those words of Sœmmerring: "Continua medulla oritur."

row, and that the reason of this nerve taking a course different from the other nerves of the encephalon is, because it is connected with that column of the spinal marrow which orders the actions of respiration.

FIFTH PAIR OF NERVES ; GRAND SENSITIVE NERVE OF THE HEAD AND FACE.

The fifth nerve of the brain arises from the fore and lowest part of the crura cerebelli, where they unite with the pons Varolii. The origin of this nerve may be divided into two portions ; an anterior is small, and somewhat elevated above the other. The posterior part of this origin take its rise a little lower than the anterior part, and is broader and flatter. These two origins of the nerve are connected by a cellular membrane, and have betwixt them a little groove, in which not unfrequently an artery creeps. According to Santorini, the anterior of these divisions is formed by the transverse fibres of the pons Varolii, and the posterior by the crura cerebelli. Vicq d'Azyr could never, except in one dissection, perceive that any of its fibres arose from the pons Varolii.*

* If we turn to Vieussens, we find this description of the origin of the 5th. "Ista "nervorum conjugatio, quam habita positionis ratione quintam numeramus, truncis "amplis a lateribus processus a cerebello ad medullam oblongatam oritur. Hæc pluri-"bus quidem fibris constat, quarum aliæ sunt molles, aliæ duriores, et aliæ ab aliis facile "separari possunt, licet simul colligatæ sint. Quintæ conjugationis nervos interdum, "juxta ipsam originem, in duos truncos divisos, crassa meninx investit." Vieussens, 1716.

Santorini has given an elaborate description of the course of the two roots in arising from the brain. Their common origin is from the extreme lateral part of the pons Varolii. One set of fibrils springs directly out from the point, where the striæ of the crus cerebelli are beginning to form the bridge, so that it is difficult to say whether they come from the crus cerebelli or from the proper medullary striæ of the Pons. The other distinct set of roots can be seen coming from a considerable distance : this fasciculus may be traced passing in between the fibres or striæ of the pons Varolii, taking first a transverse and then a longitudinal course under the pons, and it may be followed even as far as to the space between the corpora olivaria and pyramidalia ; where, on account of its delicacy, it is lost.

The following is the description given by Vicq d'Azyr at Plate xvii. Two distinct portions form the Trigeminus : the one (46.) is posterior, and the other (47.) is anterior. The first is much the most considerable from its size : and I have counted in it as many as thirty small fasciculi or nervous filaments, united together by means of an extremely delicate cellular tissue. The filaments composing the anterior portion (47.) are less numerous and less adherent. There is sometimes a small artery dividing the one of these portions from the other ; and I have likewise seen a little tract of white matter, prolonged from the tuber annulare, separating them in a similar manner. Both Wrisberg and Sœmmerring have described this substance, which was first pointed out by Newbawer. According to Santorini, the posterior root arises from the transverse fibres of the pons Varolii, and the anterior arises from the crura of the cerebellum. But frequent observations have led me to believe that both the portions of this nerve arise equally from the crura cerebelli ; at least they do so in a great measure. To be convinced, it is only necessary to make a slice with the knife just between the two roots, and to prolong the cut in the direction of the cerebellum ; then it will be plainly seen that some of the filaments extend even as far as to that part : but to observe this, the brain must be sufficiently firm, and all the care which is necessary for so nice an investigation must be taken.

Scarpa, in describing the fifth pair, says : "Par quintum duobus germinat initiis, "minore uno, majore altero : minor seu anterior e superiore et elatiore pedunculi cere-"belli oritur ; major potius ex media pedunculi linea aut ex medio margine. Binæ "istæ portiones paris quinti separatæ incedunt per aliquod spatium intra cranium, "deinde una coalescunt."—*Annot. Anat.* lib. i. cap. iii.

This fifth nerve, the largest of the skull, passing forwards and downwards, slips in betwixt the lamina of the dura mater, opposite to the point of the pars petrosa of the temporal bone. It is here firmly attached to the dura mater, and forms a flat irregular ganglion. This ganglion (the Gasserian ganglion) is formed entirely by the posterior portion of the nerve ; the anterior portion passes the ganglion, and enters the foramen ovale. From this great nerve there pass out three branches, hence the term trigeminus is given to the fifth :—1st, One to the socket of the eye and forehead, through the foramen lacerum ; 2d, One to the upper jaw and face, through the foramen rotundum ; and 3d, One to the lower jaw and tongue, passing through the foramen ovale. As I have explained in the introduction to the nerves, this fifth nerve of Willis is the upper or anterior of the regular system of nerves. It is to the head what the spinal nerves are to the body. It is a double nerve, bestowing sensibility on the head and face, and supplying muscular branches to the muscles of the jaw.

SIXTH PAIR OF NERVES ; OR, ABDUCENTES.*

The sixth nerve of the skull seems to arise from betwixt the pons Varolii and medulla oblongata. In the origin of its fibres it has, however, much variety ; and authors differ very much in this point of the description.† We may say, however, that the sixth pair of nerves arise from the corpora pyramidalia. — Sometimes the nerve rises in two branches, which do not unite until they are entering into the cavernous sinus.‡ The sixth nerve is in size somewhat betwixt the third and fourth : it passes forward under the pons Varolii, until near the lateral and lower part of the body of the sphenoid bone : it thence continues its route forwards and downwards, by the side of the carotid artery, through the cavernous sinus : here it seems increased in size. It gives off that small twig which anatomists account the beginning of the great sympathetic nerve. This communication often consists of two nerves ; and there is seated on the carotid artery a small square ganglion, which sends branches to the sixth, fifth, and sympathetic. The sixth nerve, after giving off this communication, passes on through the foramen lacerum to the abductor muscle of the eye.

SEVENTH PAIR OF NERVES ; OR, AUDITORY.

The seventh nerve arises from the posterior and lateral part of the pons Varolii, at the point where it is joined by the crura cerebelli.

But this seventh pair of Willis consists of two parts ; the facial nerve or portio dura, and the auditory or portio mollis ; the last is the larger and posterior portion.§

* Or, motores externi.

† Simple as the anatomy of the nerve is, Vieussens, Morgagni, Lieutaud, Winslow, Sabbatier—all differ in their account of the origin of this nerve in some little circumstance ; and Vicq d'Azyr gives six varieties of it.

‡ Sabbatier. Scarpa, loc. cit.

§ And we may add a third portion ; the portio media of Wrisberg.

The PORTIO DURA comes out from the fossa formed betwixt the pons Varolii, corpus olivare, and corpus restiforme* ; and upon a more careful examination we find it rising distinctly from the superior point of that column of the spinal marrow which gives origin to the par vagum, spinal accessory, or glosso-pharyngeal nerves.

The origin of the portio mollis of the seventh pair is to be traced from the fore part of the fourth ventricle.† We observe passing obliquely upwards from the calamus scriptorius several medullary striæ, which vary in number from two to seven, and are sometimes very indistinct.‡ To these are added certain fibres arising from the pons Varolii, which altogether constitute the portio mollis. The whole of this portio mollis is larger than the third nerve, firmer than the first, but less so than the second pair. It forms a kind of groove which receives the portio dura. They are divided by a small artery which comes off from the basilar to supply the ear. The portio mollis and portio dura entering the meatus auditorius internus of the petrous bone, the former is divided into four portions which pass to the several parts of the internal ear, while the latter traverses the petrous portion, and comes out by the stylo-mastoid foramen behind the ear, spreads upon the cheek, and forms the principal nerve of the face : that nerve which commands the muscles of the face.

EIGHTH PAIR OF NERVES.

To understand a very intricate demonstration, it is necessary to recollect that the eighth pair of nerves, as they have a relation to the brain, consists of three distinct nerves.—These are 1st, The GLOSSO-PHARYNGEAL NERVE ; 2d, The PAR VAGUM ; 3d, The SPINAL ACCESSORY.—Taken altogether, they arise from the superior and lateral part of the medulla oblongata, from that part which I consider the respiratory column of the spinal marrow.

The GLOSSO-PHARYNGEAL NERVE is only distinguished within the skull as a larger filament of the eighth pair ; it is, however, distinct in its course from the origin of the point where it pierces the dura mater ; it is the uppermost of the fibres of this pair of nerves. Sometimes there is a very delicate filament running parallel with its lower edge, which belongs to it. It has the same origin with the fibres of the par vagum.§

* " Fosse de l'éminence olivaire," of Vicq d'Azyr.

† Prochaska, speaking of the fourth ventricle, continues thus :—" Super has ultimas " eminentias solent medullares candicantes quasi fibræ decurrere, a quibus proprie ori- " ginem portionis mollis nervorum auditoriorum saltem pro parte deducunt." (Ridley, Haller, Lobstein, cum per antiquo auctore Piccolhomini et etiam recentissimus Sœmmerring.)—" Ego postquam multoties in lineas illas medullares in quarto ventriculo " inquisivissem, dicere possum, non semper illas in originem nervi acustici mollis termi- " nare ; nonnunquam enim paulo supra nonnunquam paulo infra desinunt, aliquando " in uno latere, et haud raro utrinque desiderantur, ita ut ex his observationibus per- " suadear illas medullares quarti ventriculi strias ad originem portionis mollis nervi " acustici minime essentiales esse." Prochaska, tab. iii. f. f. Scarp. loc. cit.

‡ It is a curious circumstance, should future observation confirm it, which has been mentioned by Santorini, that those origins of the auditory nerve have been observed particularly strong in a blind man, whose hearing had been very acute.

§ " Nervus glosso-pharyngeus fasciculo, mox una, mox duabus, quatuor, quinque " fibris composito, oritur ex summa atque priore parte medullæ pone corpora olivaria

The PAR VAGUM is composed of ten or twelve very small filaments, which are sometimes united into three or four fasciculi. These filaments arise from the outer border of the corpus olivare, or from the lateral part of the medulla oblongata.* A few fibres are to be traced from the side of the calamus scriptorius of the fourth ventricle.

The SPINAL ACCESSORY NERVE comes up from the spine to join the par vagum; it begins by small twigs from the middle column of the spinal marrow below the roots of the fourth, fifth, sixth, and even the seventh cervical nerves. In the size, length, and origin of those little slips there is much variety. As the nerve ascends to the top of the spine, it connects itself with the sub-occipital nerve; it then passes behind the trunk of the vertebral artery, approaches the par vagum, and receives some filaments from the medulla oblongata.—Those three nerves, the glosso-pharyngeal, par vagum, and accessory nerves, in their passage out of the skull, are connected in a very intricate way. They then separate from each other. The anterior branch, the glosso-pharyngeal nerve, goes to the tongue and pharynx; the middle nerve, the par vagum, has an extensive course through the body, and finally terminates in the stomach; the lowest nerve, the accessory, passing into the neck, perforates the mastoid muscle, and distributes its branches amongst the muscles of the shoulder.

NINTH PAIR OF NERVES; OR, LINGUAL; THE MUSCULAR NERVE OF THE TONGUE.

The ninth nerve of the skull originates from betwixt the corpora pyramidalia, and olivaria; from that column which gives off all the motor nerves. It is composed of several little filaments; those unite into a fasciculus of a pyramidal shape: still those filaments do not form a nerve before perforating the dura mater, but pierce it severally†; they then unite and pass out of the skull by the condyloid foramen of the occipital bone; they are then connected with the eighth pair and ganglion of the sympathetic nerve. The final distribution of the nerve is to the muscles of the tongue.‡

THE TENTH; OR, SUB-OCCIPITAL NERVE.

From its origin, its manner of passing betwixt the skull and first ver-

"nervum facialem inter atque nervum vagum, nonnunquam etiam ex quarto ventriculo "vel ex cruribus cerebelli ad spinæ medullam, nonnunquam sub posteriori sulco nervi "vagi, deductus ab eo vel distinctius, vel obscurius, interposita arteria, vel vena, vel "arteria et vena simul, vel parte plexus choroidis, quid quod ipsa directione a nervo "vago est distinctus." Sœmmerring.

* Some filaments, according to Vieussens, Santorini, and Sœmmerring, are derived from the side of the 4th ventricle.

† The ninth pair of nerves often differ very much in one side from the other, in regard to the origin and number of those fasciculi.

‡ "Forsan etiam nimio sanguine plena arteria vertebrali pressus læditur, ut inde "hæsitantia atque resolutio linguæ ebriorum, ex cerebri phlegmone insanientium, atto"nitorum explicari possit.—Collapsa vero eadem arteria ex nimio sanguinis profluvio, "lingua ob sanguinis forsan defectum resolvitur.—Ex ejusdem nervi nexu cum nervis "cervicalibus vocis jacturam post læsam spinalis medullæ partem quæ in cervice est, "explicarunt."

tebra, and its distribution, it must be classed with the nerves of the spine. It is of the class of symmetrical nerves, being double in its roots, and performing the double office of giving sensibility and motion.

The nerves of the spine are divided into the eight cervical, twelve dorsal, five lumbar, five, and sometimes six or seven, sacral nerves.* Each of those thirty nerves arises by two fasciculi, one from the fore, and the other from the back part of the spinal marrow. They are to be traced a great way in the length of the spinal marrow before they pass the membranes. The posterior and anterior fasciculi penetrate the dura mater separately, and afterwards unite. The posterior fasciculi, before they unite with the other, swell into a little ganglion; those of the cervical nerves communicate with each other by intermediate filaments. And these considerations carry us back to the view delivered in the introduction.

OF THE VEINS AND SINUSES OF THE BRAIN.

In proportion to the intensity with which the function of a part is performed is its supply of blood. The brain is very profusely supplied with blood; in so much, that it is estimated that four times more blood circulate here than in any proportionate weight of the body. This is the most moderate calculation, and it has been formed from a comparison of the quantity of blood circulating in the head with that which circulates in the arm. Boerhaave and Kiel, comparing the area of the arteries of the cerebrum with that of the ascending aorta, made a most erroneous calculation of the proportion of blood circulating in the brain, compared with that of the rest of the body. Had they compared the quantity of blood within the head with that of the lungs, of the liver, of the spleen, or of the kidney, the difference would have been less striking.

Wherever there is great arterial vascularity, we are sure to find also peculiarities in the venous system of the part; wherever we find an accumulation of tortuous arteries passing to a gland, we shall also find the veins tortuous and large.

The following appear on the first view to be the most striking peculiarities in the veins of the brain: their size; the little connection they seem to have with the surrounding cellular membrane, and the inconsiderable support which they appear to receive from it; their having no valves; their being in their course distinct from the arteries; and lastly, their not being gathered into great trunks, but emptying themselves into the sinuses of the dura mater.

It is not easy to conceive how the veins of the brain should have been so much overlooked by the older anatomists; but from the dissections of Albinus, and the microscopical observations of Lieuwenhoeck, we have authority for what is, perhaps, in itself sufficiently evident, that the veins of the surface of the brain are derived from minute ramifications conveyed in the delicate pia mater; and that these, as in the other parts

* "Plerumque quinque sunt, nonnunquam sex, raro tres vel quatuor." Sœmmerring.

of the body, proceed from the extremities of the arteries, without any apparent peculiarity in the connection betwixt the extremities of the arteries and the veins of the brain.*

I divide the veins of the brain into the external and internal: or those which emerge from its substance, and are seen upon the surface; and those which, coming chiefly from the sides of the ventricles, are convoluted in the plexus choroïdes, and terminate in the fourth sinus.

OF THE VEINS WHICH ARE SEEN UPON THE SURFACE OF THE BRAIN.

Vicq d'Azyr has been minute in his attention to the veins of the surface of the brain. He confirmed the observation, that almost all the veins which pass into the longitudinal sinus open in a direction contrary to the stream of blood in the sinus.† These superficial veins of the surface of the hemispheres are in number generally from ten to fifteen on each side. They really do not seem to be worthy of the minute attention which Vicq d'Azyr has bestowed upon them: he has most carefully described each individual branch, and that not in general terms, but first those of the right, and then those of the left side. Now, although these veins do not enter the sinus opposed to each other, nor in pairs, still the irregularity is trifling, and, were it important, does not admit of description. Those veins do not lie in the sulci of the brain, but pass occasionally along the interstices, or over the convolutions of the brain; they take in general a course from before backwards, but previous to their entering the sinus, are turned forwards. We have already observed, that the pia mater and dura mater have no connection, but at the place where those veins enter the lamina of the dura mater; and here their connection is somewhat peculiar. It is not a simple adhesion of the pia mater and dura mater; but a white spongy substance seems to connect and strengthen them, and, when torn asunder, it leaves a soft fatty kind of roughness upon the pia mater. These appear to me to be the same bodies which Ruysch so frequently mentions as little particles of fat, and which others have taken to be the glands of the pia mater.‡ Vicq d'Azyr, in his xxxiiid plate, fig. 14, has confounded them under the

* The observation is trivial; but we must recollect that Vesalius contradicted Galen, and affirmed that the sinuses received also arteries, which gave them their pulsation. This opinion was refuted by Fallopius, but adopted by Vieussens, Wepfer, and others, upon the idea of the facility with which injection passes from the arteries into the sinuses. See Ridley, cap. vi. de Cerebri Motu, ejusque Sinubus.

† From Vicq d'Azyr's table we should be led to conclude, that the veins did not decidedly all open with their mouths opposed to the stream of blood. Ridley asserts, that one half open backwards. Santorini also observes great variation in the direction of these veins. Lower, while he observed this direction backwards, describes them, at the same time, as passing obliquely betwixt the coats, like the gall-duct in the intestine, or the ureters into the bladder. Sabbatier says decidedly, that they enter with their mouths opposed to the course of the blood in the sinus. From Malacarne we should be led to conceive (what I believe to be the truth) that they open very irregularly.

‡ "Portio piæ matris in liquore, cujus superficies exterior obsita variis particulis "prominentibus exiguis, quas pro glandulis habuerunt nonnulli: cum autem sint di-"versæ formæ, et colore pinguidinem repræsentent, pro pinguidine potius illas habeo, "præsertim cum inter duplicaturam piæ matris aliquoties pinguidinem invenerim." Thesaurus Anat. ix. N. xlii. Epist. ix. p. 8. Thes. v. No. 1.

name of the glandulæ Pacchioni.* Of these veins lying upon the surface of the brain there is one, or very often there are two large veins on each side, and which enter generally pretty far back in the sinus, and are somewhat peculiar, from their greater size, and their semicircular course. These, from their state of dilatation, and the colour and fluidity of their blood, will be found in morbid dissection to mark sufficiently, in many instances, the character of the venous system of the brain. There is again another vein somewhat peculiar in its course; whilst those take a superficial course, and are upon the level of the longitudinal sinus, it gathers its branches upon the internal flat surface of the left hemisphere, and rises so as to insinuate itself into the inferior part of the sinus.† All these veins of the surface of the cerebrum have very free inosculations with each other.

I cannot any where better observe the negligence of authors, in regard to the glandulæ Pacchioni, than when speaking of the mouths of those veins which open into the great longitudinal sinus.

I cannot help thinking that many of our best authors have overlooked entirely the importance of the glandulæ Pacchioni; and many also have been entirely ignorant of them. We have already mentioned, that a few small bodies, by no means constant or regular, were to be seen upon the external surface of the dura mater, in the course of the longitudinal sinus, or at no great distance from it. We have mentioned also those fatty-like adhesions of the roots of the veins, as they enter the sinus, and which rather belong to the pia mater. Both these are called the glandulæ Pacchioni improperly. The bodies which engaged Pacchioni and Fautonus in such violent disputes are seen on the inside of the longitunal sinus, and are connected with the openings of the veins‡; they appear of a fleshy colour, projecting like papillæ, or like the granulations of a sore. Pacchioni says, "Ovorum instar bombycinorum apparent," which describes their conglobate appearance; but they are of a pale fleshy colour, which Pacchioni says is owing to their being surrounded with muscular fibres. The preparation from which Pacchioni had taken his plate was previously macerated in vinegar. These bodies, being

* We see also what he says in the Acad. of Sciences, An. 1781; p. 502. "Elles "étoient plus ou moins recouvertes, vers leur insertion, par les glandules de Pacchi- "oni: les ayant examinés dans plusieurs sujets, j'ai observé qu'elles étoient a peu-pres, "de chaque côté, au nombre de dix, douze, ou quinze." Ridley calls these "carnous adnescences" betwixt the membranes, p. 8. As to the glands which Willis affirms to be scattered over the tunica arachnoides, I could never see them. Ridley.

† Vicq d'Azyr.

‡ "In longitudinali sinu, immediate sub membranosis expansionibus, in areolis chor- "darum Willisianarum, quin et supra easdem chordas, consitæ sunt innumeræ glan- "dulæ conglobatæ, propria, et tenuissima, membrana, veluti in sacculo conclusæ; quæ "racematim ut plurimum coeunt; raro sparsim disponuntur: hæ glandulæ utrinque "ad latera falcis messoriæ, ab ejusdem apice ad basis usque posticam partem miro "prope modum artificio procedentes, dorso lacertorum accumbunt, et partim ab horum "fibris, partim ab iis quæ a chordis emergunt, firmantur, atque invicem alligantur, ita "ut non nisi lacerat acu disjungi possint." Vide Pacchioni, p. 126.

"Sinu longitudinali aperto, in conspectum veniunt corpuscula rotunda, & subrotun- "da, milii forma (a clariss. viro Pacchiono detecta): hæc magnitudinem aciculæ vulga- "ris caput haud superant, nisi per microscopium introspiciantur, aut ex duobus cor- "pusculis combinentur." Ruysch, Thes. vii. No. xxxiv. From this we see how various the size of these bodies is. In the next paragraph he observes, "Vix et ne vix "quidem ullum ex dictis corpusculis videre potest."

soft and vascular, have allowed the minute injection to transude in some of the experiments of anatomists, which has given rise to the opinion of the actual communication of the arteries of the dura mater with the sinuses. As to their use*, I am in considerable doubt. Joan. Fautonus (in his letters to Pacchioni) conceives that they give out a fluid into the sinus, to dilute the venous blood.† Pacchioni describes ducts passing from them to the pia mater, (which are those connections that we have already remarked,) and conceives that they lubricate the surface, or communicate with the substance of the brain; and that they are pressed, and their secretion promoted, by the motion of the chordæ Willisianæ, and the action of the dura mater.‡

I should rather conceive that they had a valvular action on the mouths of the veins; they project from the mouths of the veins in the sinus, and the blood passing from the veins must filter through them, and be checked in its retrograde course. This check we know to be very necessary, since the blood flows backwards through the sinuses with a powerful impetus. As these bodies differ very much in the variety of subjects, they must sometimes impede the free egress of the blood from the veins of the cerebrum into the longitudinal sinus, and cause disease, especially as they are softer and larger in old men.§ At all events, they are too much overlooked in morbid dissection.

The veins which answer to the arteria corporis callosi, and which are seen lying upon the corpus callosum in a very fine cellular membrane, rise and pass into the inferior longitudinal sinus, that sinus which is formed in the laminæ of the inferior edge of the falx.

OF THE INTERNAL VEINS OF THE BRAIN AND OF THE CHOROID PLEXUS.

Under this title of the internal veins of the brain, the choroid plexus comes naturally to be considered. The most remarkable thing in the ventricles of the brain is, the choroid plexus. The lining membrane of these cavities is extremely thin and smooth, insomuch that some anatomists have denied its existence; but through the whole ventricle there runs certain folds or plaits of this membrane, which are so loaded with vessels as to resemble a fleshy substance, and thus lose their resemblance of the lining membrane. The plaits, before they are unravelled, look

* It is curious that these bodies are confined to the longitudinal sinus. "Mirum, "et æque animadversione dignum est, hasce glandulas ad solius longitudinalis sinus "latera reperiri cum in lateralibus sinibus vel nunquam, vel raro admodum per pauca "earundem vestigia adnotentur, ubi præsertim præfati canales deorsum inclinare incipiunt, antequam ab interseptorum dorso discedant." Pacchioni, p. 127.

† "Ego aqueum humorem in glandulis egregari, fluere lympham in tubulis, quos tecum lymphaticos appello, nunquam negaverim; sed liquidi fluxum ab utrisque versus sinum, magis quam versus ambitum cerebri verisimilem, magisque naturæ legibus consonum, esse affirmo." Fautonus Epist. D. A. Pacch. Oper. Pacch. 177.

‡ "Ex iis autem in minimum quidem vasculum lymphaticum prodire conspicere potui." Ruysch.

§ "Fibris carneis tenuissimis circumambiuntur singulæ, unde colorem carneo-pallidum nancisci videntur: in senibus vero, in quibus hujusmodi fibræ enervatæ nimis laxantur, et ferme disparent, glandulæ albescentes, et magis turgidæ cernuntur: quod, "et in hydrocephalicis, comatosis, et id genus aliis observari posse arbitrarer." Pacchioni Oper. p. 126, 127.

like masses of tortuous vessels, lying loose and unconnected in the bottom of the ventricles.

The largest portion of each choroid plexus comes up from the inferior horn of the lateral ventricle, and runs forward in a direction to the anterior horn. It lies in the groove betwixt the thalamus nervi optici and corpus striatum, and covers the tenia semicircularis geminum. The two plexus of the lateral ventricles unite under the anterior crus of the fornix, and form a small plexus, which is continued upon the inferior surface of the velum interpositum, and even into the third ventricle. Again, there is another plexus which lies in the fourth ventricle. Vicq d'Azyr describes, as occasionally occurring, little insulated plexuses attached to the veins, branching on the corpora striata.*

Very often we find the portion of the plexus, which is ascending from the lateral ventricle, thicker and firmer than natural, and sometimes it has in it small bodies like glands, which, however, are of the nature of hydatids or vesicles, and are a production of disease or over excitement.† A foolish notion prevailed, that the blood accumulated in these convoluted vessels occasioned such a gentle continued heat as favoured the circulation of the spirits through the cavities of the brain, and preserved the fluidity of the water of the ventricle.‡ Great variety of opinions have prevailed regarding the structure of those bodies. We see them consisting of knots of convoluted vessels, chiefly veins; or these at least are most evident, from their size, and the colour of their blood. It is these convolutions of vessels which are by many good anatomists described as glands. Varolius, Sylvius, Wharton, Willis, Santorini, and Lieutaud consider them as such.§ Three sets of ARTERIES pass up to the PLEXUS CHOROIDES, from the base betwixt the crura of the brain; they come, 1st, from the curve of the internal carotid artery; 2d, from the communication betwixt the basilar and carotid artery; 3d, from the basilar artery and posterior part of the branch of communication. These arteries, which are small, are convoluted in their course, and run into great mi-

* "Sur le côté des ventricules latéraux, j'ai quelquefois observé de petits plexus "choroides isolés, qui accompagnoient quelquefois de ces rameaux des veins de Ga- "lien, que l'on voit passer sous le tænia semicircularis, et s'etendre sur le corps strié." Vicq d'Azyr, Memoir. l'Acad. Roy. 1781, p. 540.

† The supposed glands of the plexus choroides were conceived to secrete the fluid of the ventricles. Where the plexus lies upon the posterior crura of the fornix, it is often diseased, having knots like glands, or being raised into vesicles like hydatids, "Eas bul- "las humorem ventriculorum secernere olim conjectura fuit. Verum vitio cum nascan- "tur vix perpetuum habitum generare idoneæ erunt." Haller, tom. iv. 48.

‡ See Duverney, tom. i. p. 55. "Ut enim sanguis intra sinuum cavitates aggestus, "Balnei calidioris vicem prestat, quo spiritus animales in extima et corticali cerebri "parte uberius distillentur: ita sanguis intra plexus hujus vasa exilia contentus, quo "iidem spiritus in penitiori ac medullari substantia idonei circulentur, Balnei minoris, "et magis temperati loco esse videtur." Willis Cerebri Anat. p. 47.

§ Galen gives a good description of the choroid plexus; he describes the innumerable veins of which it is composed, and their joining the fourth sinus by the vein which retains his name. Some have confused themselves with a passage of Ruysch, Thes. iii. No. lxv. &c. in which he is speaking of the choroid plexus, where it appears in the base of the skull from the bottom of the fourth ventricle. They have understood him to say, that the plexus was covered, not with the pia mater, but with the tunica arachnoides, first described by Morgagni, and whose authority we may consult for much of this part of anatomy. Adversar. Anat. vi. Animad. 1. et sequent.

nuteness* in the membrane, and their blood is returned by veins, which, taking a very tortuous course, seem to entangle their branches, and form a confused mesh.

I conceive the use of these loose and vascular membranes is to secrete the fluid of the cavities. They are undoutedly the parts of the brain the most excitable ; for if but a temporary change takes place in the circulation of the blood in the brain, it will upon dissection be manifested in the state of fulness of these veins, in the vesicles which are formed in their folds, and in the accumulation of fluid in the ventricles themselves.

The blood of the two plexuses of the lateral ventricles, and that of the third, is conveyed into the velum interpositum, or that membrane which stretches under the fornix and over the third ventricle. The branches of veins also which extend themselves upon the sides of the lateral ventricles, and into the processus digitalis, being gathered together upon this membrane, open into the vena Galeni, or rather form it.

The most remarkable branches of veins in the lateral ventricle are these : a considerable vessel is seen to collect its branches upon the anterior part of the ventricle, and in the anterior sinus, or horn of the ventricle. This vein runs back towards the anterior crus of the fornix, and dips under it, just above the communication of the ventricles, and joins the veins in the velum of Haller. Other small veins are seen collecting their branches upon the corpora striata ; and, passing under the centrum semi-circulare geminum, connect themselves with the plexus. Again, several branches of veins are extended in the posterior part of the ventricle. These are from the medullary substance of the posterior lobe of the cerebrum. They pass under the posterior crus of the fornix, and join the vena Galeni. Lastly, a vein remarkably tortuous, frequently full of blood, passes forward, and is seen at intervals in the plexus choroides. This vein, taking an acute turn, joins its fellow under the anterior crura of the fornix, and is reflected backwards and under the fornix, so as to form the beginning of the vena Galeni.

The VENA GALENI then is the great central vein of the brain. It stretches from the extremity of the fourth sinus into the internal part of the brain, to receive the blood from the membrane lining the ventricles,—from the substance of the brain,—from the plexus choroides,—and from the velum interpositum.† It lies under the posterior part of the corpus callosum, under the fornix and above the nates and testes. It is entangled in the velum itself. It consists of two great branches which lie parallel to each other, and which sometimes have the appearance of being twisted, and these unite before they enter the fourth or strait sinus.

In the BASIS of the BRAIN the veins are not remarkable, nor do they require any description distinct from the sinuses into which they open.

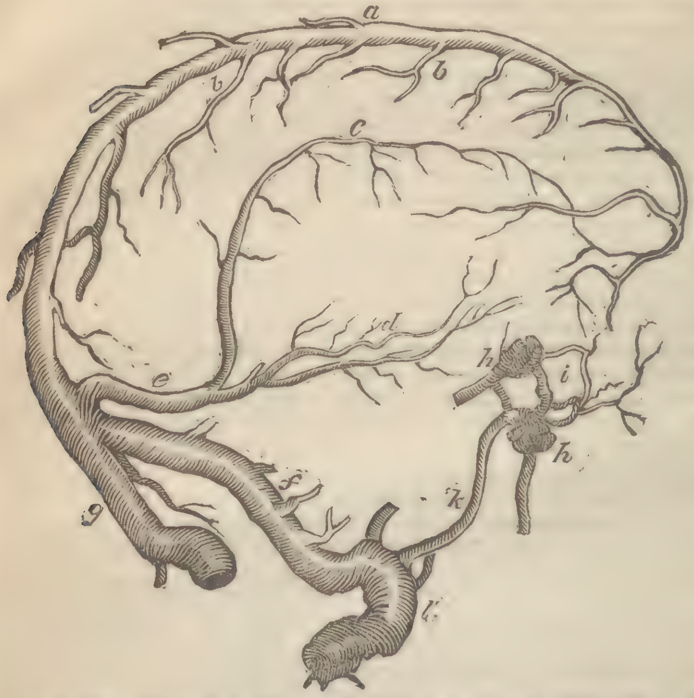
They are small, having little way to run ; and before they become large trunks, they empty themselves into the numerous lesser sinuses

* "Huncce plexum nil esse nisi arteriolas, ad visum succosas, a naturali constitu-"tione arteriosa non nihil recedentes, mirumque in modum contortas, serpentinoque "modo reptantes, glandulasque representantes." Ruysch, Thes. v. Asser. quartus, No. lxviii. Not. 2.

† The velum lying upon the nates and testes, and adhering to them and the pineal gland ; the vena Galeni receives here also veins from those bodies, and from the upper part of the cerebellum.

betwixt the dura mater and the base of the skull. This is, perhaps, a provision against the pressure of the brain. In passing into those sinuses, the veins take a long oblique course betwixt the lamellæ of the dura mater; which has given occasion to anatomists to describe many intricate lesser sinuses.

OF THE PARTICULAR SINUSES.



(*a*) The great longitudinal sinus; (*b*) superficial veins; (*c*) the inferior longitudinal sinus; (*d*) the vena Galeni; (*e*) the fourth sinus; (*f*) the right lateral sinus; (*g*) the left lateral sinus; (*h*) the cavernous sinus; (*i*) the circular sinus; (*k*) the petrous sinus; (*l*) the jugular veins.

By the term sinus we are to understand the great veins of the brain, where they are received into the triangular canals of the dura mater.

SUPERIOR LONGITUDINAL SINUS.

This is a triangular channel running into the falx from the crista galli of the æthmoid bone to the crucial ridge of the occipital bone. It is not constant in its origin. Sometimes it begins from a blind foramen before the crista galli.* Sometimes from the orbital sinus.† In some subjects

* Malacarne, Haller, Gautier.

† These sinuses as frequently are continued into the inferior longitudinal sinus, or

it begins only opposite to the fontanelle, or even further back, and then at once swells out to a large size.

As the sinus passes backwards it is gradually enlarging for the reception of the veins from the surface of the cerebrum. The course of the sinus corresponding with the form of the skull is a curve answering to the sulcus, which runs in all the length of the cranium, from the æthmoid bone to the crucial ridge of the occipital bone. The angle formed by the splitting of the internal layers of the dura mater, to form this sinus, is strengthened by strong slips of fibres, sometimes called cordæ Willisianæ, which upon the inside of the sinus have the effect of making the canal irregular, so that it has the appearance of cells, into some of which the probe enters, and leads to the veins on the surface of the brain: others are blind, or lead to lesser sinuses, which not unfrequently run parallel for some length to the great sinus; or the probe passes from one of these cells to another. Sometimes the sinus has no such irregularities, but is straight and smooth through its whole length.*

This sinus has in some rare instances been found of a square shape; its lower surface serving as a roof for another sinus of a triangular form, which, for some way, ran parallel with the great sinus, and which was of course also included in the lamina of the falx—these Malacarne calls SENI SUBALTERNI. Irregular lesser sinuses are by no means uncommon, and they form, sometimes, communications through a great extent of the longitudinal sinus; or again it will be found that the longitudinal sinus deviates considerably in some subjects from the straight line, taking a curve or circle generally behind the fontanelle; or it sends off branches, which again unite with it; or it is fairly divided. In all these cases the chords or fasciculi of the dura mater stretch out over the sinuses, and protect them from compression.

Instead of reaching backwards to the crucial line upon the occipital bone, the longitudinal sinus has been found to divide at the beginning of the lambdoidal sutures, and to follow them in a direction towards the petrous bone;† while the lateral sinuses, running in the duplicature of the tentorium, were reduced to a very narrow compass.

From the strength of the connections of the sinuses, and from the languid course of the blood through them, I cannot believe that the sinus has ever suffered the distention which Malacarne says he has observed. I should rather suppose that what he mentions had been natural and congenital enlargements; especially considering that the sinuses, like the other veins of the body, are frequently irregular.

LATERAL SINUSES, OR THE FIRST AND SECOND OF THE ANCIENTS.

The lateral sinuses are formed by the splitting of the laminæ of the tentorium, as the longitudinal sinus is formed by the falx. They are continuations of the longitudinal or first sinus. From the crucial ridge

into the circular or elliptical sinus; they are like azure streaks under the dura mater covering the orbital process.

* The internal membrane of the sinus is perfectly smooth, and is continued into the coats of the internal jugular veins; it is of the same nature with the internal coat of the vein.

† Malacarne, part i. 148.

of the occipital bone they stretch nearly horizontally, going off right and left, following the connections of the tentorium in a direction toward the petrous bone; then they take a curve downwards and forwards, to terminate in the internal jugular vein; passing through the foramen lacerum betwixt the temporal and occipital bones.

Very frequently the one lateral sinus is larger than the other—generally the right is the larger, and sometimes the left is entirely wanting.*

They diverge from the termination of the superior longitudinal sinus at the crucial point of the occipital bone; but sometimes they are irregular, diverging higher, and even passing round in the circle of the posterior part of the cranium, at some distance from the tentorium.†

The right lateral sinus for the most part begins higher than the left. It is generally longer, and may be considered as the continuation of the longitudinal sinus. Nay, in some subjects, the right or left lateral sinus begins from the longitudinal one, while that of the other side is continued from the fourth, and then the lateral sinuses are separated at their origin by a membranous isthmus. If one of the lateral sinuses receives the superior longitudinal one, it will be found to be four times the size of the other.‡

I have seen a more remarkable variety of the lateral sinuses. The blood which should flow from all those parts of the brain from which the superior and inferior longitudinal sinus, and the vena Galeni, and fourth sinus are derived, instead of passing by the root of the tentorium, forsook these channels, and consequently the lateral sinuses were left diminutive; and the blood took a course in the tract of the posterior occipital sinuses, and after encircling the foramen magnum, they gained their usual outlet.§

The angles of the lateral sinuses are strengthened by membranous fasciculi; betwixt these the veins enter as in the longitudinal sinus; where the sinus descends from the level of the tentorium, in the angle formed by the occipital and petrous bones, there are many strong irregular fasciculi of fibres: under this point, being no longer protected from compression, by their triangular shape and the tension of the tentorium, the sinuses are irregular; they are now sunk in the sulci of the bones, and the dura mater its sheath over them.

The great irregular cavity‖, in which the extremities of the lateral sinuses lie¶, and the foramen lacerum, have much variety, and their straightness seems to affect the size of the sinus in its whole length.**

* Lieutaud, Anatom. Hist.

† Malacarne.

‡ See Morgagni Adversaria VI. tab. 1. fig. 1.

§ There are instances of the lateral sinuses opening into the external jugular vein.

‖ Lower conceives that the size of the jugular fossa was the effect of the reflux of the blood; and that the greater size of the sinus of the right side was to be traced to the practice of nurses laying their children chiefly on the right side! See also Morgagni Adversaria Anat.

¶ See Willis Anatom. Cereb. Hum. p. 29. and the plate.

** Some very large veins open into the lateral sinus: they are derived from the posterior lobes of the cerebrum and the cerebellum. These, insinuating irregularly betwixt the lamina of the tentorium, and running for some way, have been considered as additional sinuses. See Haller, tom. iv. p. 149.

OF THE INFERIOR LONGITUDINAL SINUS.

The inferior longitudinal sinus, or the lesser, or inferior sinus of the falx, runs in that edge of the falx which penetrates betwixt the hemispheres of the cerebrum. It is extremely small towards the fore part of the falx; but, as it passes backwards, it goes on increasing by the accession of veins which come from the hemispheres, and corpus callosum, and from the falx itself. It is formed betwixt the lamina of the falx. Sometimes it runs in its very edge, but as frequently a little way removed from it; sometimes it is found beginning very far back in the falx. The fore part of it is more like a vein running in the falx than a sinus. It is in general to be seen more superficial, and in every respect like a vein, (there being no provision for preserving it from compression,) upon one side of the falx. It very often takes a waving course upon the falx; while it receives veins which branch in the substance of the falx, and form communications betwixt it and the superior longitudinal sinus. It opens into the straight or internal sinus, called also the fourth, near the edge of the tentorium.

OF THE INTERNAL, STRAIGHT, OR FOURTH SINUS.*

I would call this the internal sinus, from its situation, but more particularly from its receiving the veins from the internal part of the brain. This sinus is formed chiefly by the vena Galeni; which, coming out from betwixt the corpus callosum and tubercula quadrigemina, enters betwixt the lamina of the middle part of the tentorium, where it is united to the falx; so that by the tension of these two partitions, this sinus is drawn into a triangular form, and is as incompressible as those sinuses which run connected with the bone.

It opens, for the most part, by an oval mouth, formed by strong pillars of fibres, into the left lateral sinus, rather than directly in the middle of the communication of the three great sinuses. We shall find this, like the other sinuses, suffering considerable variety; or irregular smaller sinuses will often be found running betwixt the laminæ of the tentorium.

POSTERIOR OCCIPITAL SINUSES.

These are so called in opposition to some irregular and small sinuses which run upon the occipital bone before the great foramen. The POSTERIOR OCCIPITAL SINUS lies in the little falx of the cerebellum: it rises upwards, and opens into the common union of the longitudinal and lateral sinuses; it commonly, however, lies rather to the left, and empties itself into the left lateral sinus. It is by no means constant; like the other lesser sinuses, it is subject to great variety; and before it rises into the tentorium, or empties itself into the larger sinuses, it has a communication or emissaria, by which part of the blood may pass into the external veins, through a foramen in the centre of the occipital bone.†

* Sinus quartus, Perpendicularis. Haller.—The fourth sinus; the two lateral being the first and second, and the longitudinal being the third sinus.

† Malacarne.—This sinus is sometimes double; or it has two branches encircling

THE INFERIOR LATERAL SINUSES.

The inferior lateral sinuses are still more rarely to be found than the last, insomuch that Vicq d'Azyr says he never has seen them. They run in the lamina, or under the dura mater of the posterior fossa of the base of the skull; that is, the hollow of the occipital bone, which is under the tentorium. They are so irregular that they frequently occur in one side only. They communicate with the posterior part of the foramen lacerum; with the posterior petrous sinus or vertebral veins; or, lastly, they occur as an irregular collection of channels running in the several neighbouring sinuosities.*

We see, then, that there is a point of union for all these sinuses, which we have not as yet described: we see that the superior longitudinal sinus, the two lateral sinuses, the fourth (and consequently the inferior longitudinal sinus), and the posterior occipital sinus, unite at the crucial spine of the occipital bone. This is the TORCULAR HIEROPHILI†, TORCULAR, LACUNA, PLATEA, TERTIA VENA, PALMENTUM, PELVIS, LAGUNCULA. It was natural that the attention of the ancients should be drawn to this part; for, upon opening this union of the sinuses, we find a large irregular cavity, which seems to be particularly strengthened by these strong fasciculi of fibres, which indeed are the support of the sinuses.‡ Ignorant of the circulation, imagining that the blood ascended by the great jugular veins to the lateral sinus, and seeing that the lateral sinuses opened into this central cavity, they conceived that the blood destined for the brain underwent an operation there, and was thence sent through every part of the brain.§

the posterior margin of the occipital hole; or, as I have already observed, it takes the office of the great superior lateral sinuses, and empties it into the foramen lacerum; or it communicates with the vertebral veins. See Observations sur un Dilatation singulière des Sinus Occipitaux, Mem. de l'Acad. Roy. Anno 1781. p. 596.

* "Independente dai seni lateralia inferiori ho veduta tra le robuste lamine e le fibre, "dalle quali incomincia crassissimo l'imbuto vertebrale intorno al maggior folo del "cranio una quantita di caverne, di cellule communicanti insieme, le quali formavano "un seno circolare irregolarissimo appoggiato sulla parte superiore, o sia sul margine "interno del foro medissimo." Malacarne, p. 113, 114.

† Hierophilus was a Greek physician, a disciple of Praxagoras, and cotemporary with Erasistratus.

‡ "Deinde et alia per sectionem scalpellum injiciens, sursum adigere conaberis ad "usque verticem ubi venæ duæ invicem congrediuntur; quam regionem Hierophilus "nominat lenon, torcular. Galen." Lib. Nomus de Cerebri, &c. Dissectione.

§ "Coeuntes autem in vertice capitis, quæ sanguinem deducunt meningis duplica- "turæ, in locum quendam vacuum quasi cisternam (quem sane ob id ipsum Hierophi- "lus torcular solet nominare,) inde velut ab arce quadam omnibus subjectis partibus "rivos mittunt; quorum numerum nemo facile dixerit, quod partium nutriendarum "numerus sit infinitus. Manant autem rivorum nonnulli quidem ex medio ipso loco "in totum cerebellum, secti, ac derivati, eodem prorsus modo, quo ii qui in areolis, alii "autem ex parte anteriore feruntur, ea scilicet qua torcular excipit dixeris utique velut "rivum quendam sanguinis, quem et ipsum ex crassa meninge admodum ingeniose "fabricata est, partibus enim ipsius meningis quæ sanguinem duxerent ad torcular ap- "pulsis, dimissaque illinc aliqua in partes subjectas, non amplius, quod superarat, uni "venæ concredidit, sed præterea ex crassæ meningis partibus anterioribus extensis ri- "vulum efficit, ex quo primum multos rivulos per totam viam produxit." Galen, cap. vi. *de torcular. Et quo pacto venæ intra cerebrum distribuantur.*

OF THE LESSER SINUSES IN THE BASE OF THE SKULL.

Besides those larger sinuses which we have described, and which convey back the great proportion of blood circulating in the brain, there is a set of lesser sinuses which lurk betwixt the dura mater and the anterior part of the base of the skull. These last are fully more intricate than the others; they lie upon the irregular surface of the sphenoid, temporal, and occipital bones; and tend backwards to the great embouchoir formed by the irregular hole in the temporal and occipital bones.

THE SPHENOIDAL SINUSES.

The SUPERIOR SPHENOIDAL SINUSES are seated in a fold of the dura mater, on the internal margin of the wing of Ingrassias, and before the great wing of the sphenoid bone; they receive the blood in part from the orbit and from the dura mater; they open into the cavernous sinus, or perhaps into the ophthalmic sinus, which of course, for the most part, conveys the blood into the superior or inferior longitudinal sinus.

The INFERIOR SPHENOIDAL SINUS is very irregular and inconstant. It is in the dura mater, covering the great wing of the sphenoidal bone: the blood of this sinus is emptied into the cavernous sinus, or escapes by emissariæ into the trunk of the temporal veins.

The CLYNOID SINUS.—The posterior clynoid sinus, or elliptic sinus, and the circular sinus, are one and the same; the difference consists only in the manner of describing them; the CIRCULAR SINUS lies within the clynoid processes of the sphenoid bone, and surrounds the glandula pituitaria.*

As this circular sinus opens upon each side into the cavernous sinus, it is not unaptly divided into two; the anterior half of the circle being the anterior clynoid sinus of some authors; the posterior half (which is in general wider), the elliptical or posterior clynoid sinus, or semilunar.

This sinus, like most of the lesser sinuses, is irregular in its shape, its size, its communications, and its origin.† Its natural communication is with the cavernous sinus, which in fact encroaches upon its side; it will be found to communicate also with the sphenoidal sinuses, and the oblique or petrous sinuses‡: at one time the anterior half of the circle is wanting; at another the posterior.

THE CAVERNOUS SINUS.

The cavernous sinus is a great irregular centre of communication with

* Ridley describes it in these words: "Another I discovered by having injected the "veins with wax, running round the *pituitary gland*, on its upper side, forwardly "within the duplicature of the dura mater, backwardly between the dura mater and "pia mater, there somewhat loosely stretched over the subjacent gland itself, and late-"rally in a sort of canal made up of the dura mater above, and the carotid artery on "each outside of the gland, which, by being fastened to the dura mater above, and be-"low at the basis of the skull, leaves only a little interstice betwixt itself and the gland." —Brunnerus describes this sinus.

† Malacarne, p. 123.

‡ Haller, tom. iv. p. 154.

the lesser sinuses in the base of the skull. This sinus is sunk upon each side of the sella turcica, and is formed in the irregular splitting of the lamellæ of the dura mater: it is of a triangular shape; it extends from the sides of the sella turcica to the foramen spinale. The pointed extremity of the tentorium, which extends forwards from the angle of the petrous bone to the posterior clynoid process, covers and protects it. The cavernous sinus is different from all the others; it is irregular, having fibrous cords traversing it, which give it a kind of cellular appearance. It is like a diseased part into which the blood had been driven, till the cellular texture had been distended and partly destroyed. After a minute injection, small arteries are seen to ramify among these fibres; the internal carotid artery rises through it, and the sixth pair of nerves are involved in it in their passage from the skull.

This sinus is the centre of the little sinuses and veins of the anterior part of the base of the brain and cranium: four or five veins pour their blood into it, from the anterior lobes of the brain and the fossa Silvii; sometimes, even the ophthalmic veins open into this receptacle.* The superior and inferior petrous sinuses, and the basilar sinus, open into it behind; the circular before; the sphenoidal sinuses and veins of the dura mater upon the side; while the right and left sinuses often communicate by means of the transverse sinus. Besides these, the petrous sinuses have several communications, or emissariæ as they are called, viz. into the orbit, by the funnel of the carotid artery, through which descends a vein (the vena sodalis arteriæ carotidis), which terminates in the pterygoid plexus of veins; again, veins pass out by the sphenoidal fissure.

The TRANSVERSE, OF POSTERIOR CLYNOID SINUS, runs across from one lateral basilar sinus to another behind the posterior clynoid processes.† In its form it is not peculiar, nor is it very regular.

PETROUS SINUSES.—These are three small sinuses which may be called petrous, from lying betwixt the dura mater and petrous bone: one runs near the angle formed by the pars squamosa and pars petrosa of the temporal bone; another occupies the groove on the salient angle of the bone; and the third is rather belonging to the cuneiform process of the occipital bone.

The ANTERIOR PETROUS SINUS runs upon the anterior face of the petrous bone, from near the spinal hole‡; whence, making a semicircular curve in the angle of the petrous and squamous portions of the temporal bone, it terminates in the lateral sinus.

The POSTERIOR PETROUS SINUS§ lies in that pointed extremity of the tentorium which stretches forward, connected with the acute angle of the petrous bone. It is narrow; and a sulcus or groove on the angle of the bone gives a partial lodgment to it; it passes from the cavernous sinus to the great lateral sinus.

* This vein, the vena angolana, makes a very remarkable emissaria, but it is more probable that the blood in such veins runs inwards than that it escapes from the skull to the external veins.—Cum venis posterioribus frequentes nexus init. Sœmmerring, vol. v. p. 354.

† The superior and inferior, or oblique sinus, the cavernous and the transverse, meet nearly at a point.

‡ And here it has a transverse branch of communication with the cavernous sinus, which runs under the extended point of the tentorium.

§ Or superior petrous sinus. Vicq d'Azyr.

The LATERAL BASILAR SINUS, or INFERIOR PETROUS SINUS, is shorte: and larger than the last; and it makes an oblique curve from the ca vernous sinus under the pointed extremity of the tentorium, which is continued by the side of the sella turcica to the termination of the latera sinus, or rather into the beginning of the jugular vein, by a channe separated by a bony lamina from the termination of the lateral sinus; o it is continued into a vein in the base of the cranium, which afterward joins the great jugular vein.

The MIDDLE BASILAR SINUS.—This scarcely deserves the name o sinus. It consists, in general, of a few cellular-like communications formed in strong fibres of the dura mater, which here partakes of the na ture of a ligament. These open into the last-mentioned sinus, or some times into the vertebral vein.

The VERTEBRAL SINUSES are veins included in the lamellæ of the dura mater; and, divided into right and left, they descend into the tube of the vertebræ on its fore part, and pass down even to the sacrum. They are connected in all their length with the vertebral, dorsal, and lumbar veins These sinuses or veins, at each vertebra, are joined by a transverse branch; they are connected at the top of the spine with the basilar or anterior occipital sinuses.

EMISSARIÆ SANTORINI.

"VENÆ EMISSARIÆ" is but another term for those lesser veins which form communications between the sinuses within the head, and the external veins in the base of the cranium. These, then, are chiefly the ophthalmic*, mastoidean, and vertebral veins. But the vena sodalis arteriæ carotidis, the small vein which penetrates the parietal bone by the side of the sagittal suture, even the venæ arteriæ meningeæ sodales, and the little veins which pass with some of the nerves, or through the fissures of the bone, are also brought into account. To these a much greater importance has been attached than they merit; particularly in apoplectic affections of the head, they have been supposed to be eminently useful in emptying the surcharged sinuses and veins of the brain into the external veins.

But those lesser passages for the blood, supposing us to be assured that the blood flowed through them from the sinus to the external veins, are insignificant, when compared with the great outlet of the INTERNAL JUGULAR VEIN; to which we have seen all the sinuses tend. But the accumulation of blood in the vessels of the brain is seldom mechanically produced: it is a diseased action of the system of the brain, to which we become more and more liable as we advance in years: and perhaps it is owing to the same gradual change which is operating on the venous system from infancy to old age.

The importance of the sinuses in the circulation of the blood in the brain does not appear to be perfectly understood, at least judging from

* "Je me suis convaincu, par des dissections multipliées, que les sinus caverneux et "orbitaires communiquent, par un plus grand nombre de veinules, avec les arrières-na- "rines, de sorte que les hémorrhages critiques qui se font par le nez, dans les fièvres "aiguës ou la tête est affectee, s'expliquent facilement par ce moyen," &c. Vicq d'Azyr, **Acad. Royale, 1781, p. 504.**

the expressions of authors. We find it said, that the sinuses support the blood against compression, and protect its free circulation. This may be one use of the structure which is peculiar to these veins, but surely not the principal one.

Another conception of the use of the sinuses is nearer the truth; viz. to prevent the sudden and violent action of the muscles of respiration, or of the muscles of the head and neck, from injuring the smaller veins of the brain; that the sinuses prevent that impulse from being communicated to the blood in the small and tender veins of the brain, which might endanger a rupture of them.* Yet this is not exactly the manner in which the sinuses preserve the lesser veins; they do not suffocate nor take off the force of the impulse from the regurgitating blood so much as they would do if they were, like the trunks of veins in other parts, distensible; because, being incapable of distention, they throw the undulation of the blood (when it is thus checked in its exit,) backwards upon the extremities of the veins. But then the effect is, that no particular vein or trunk receives the shock; all suffer in a lesser degree, and equally, which is their safety. All the veins in the base of the brain, which would be liable to rupture, or distention, from receiving, in their sudden turns, the shock of the blood, are preserved by being inclosed in sinuses, and covered by the strong lamellæ of the dura mater. The lesser vessels again are removed from the shock: its force is spent, because it has spread among many branches; and it has become a general impulse upon the brain, which the brain resists, because it is incompressible.

That the brain does receive such an impulse, in violent coughing and straining, is sufficiently evident from the rising of its surface seen on these occasions, when it is accidentally laid open by fracture or the trepan.†

We ought not to confound the idea of incompressibility of the brain with that of a solid substance, which would allow no motion in the vessels within the cranium, and would require us to invent some specious means to account for the circulation of the blood in the brain, different from that of the other viscera of the body. Were the brain thus incompressible, or rather solid, so as to prevent a free action of the vessels within the cranium, then, as the blood enters with an evident pulsation, it must necessarily have returned by the veins with a distinct pulsation. We accordingly observe that whenever the surface of the brain is exposed it is seen beating. When pus or blood is forcing its way from under the cranium, we can see that a pulsation is communicated to it; and in the oozing out of blood from the longitudinal sinus, I have perceived the same pulsation. When the blood is sent into the arteries of the brain by the stroke of the heart, they dilate; and this dilatation the pliability of the brain allows, by throwing a comparative degree of pres-

* Monro, Nervous System, p. 4.

† The older physicians, observing the connection betwixt the motion of respiration and of the brain, conceived that the air was drawn through the nose and cribriform bone into the brain, so as to distend it. Upon this hypothesis followed many wonderful cases.

We have already mentioned the hypothesis which supposed compression and relaxation of the cerebrum and cerebellum alternately, by the action of the falx and tentorium.

sure upon the veins. Again, when the arteries (during the dilatation of the heart) are in action, and contract, their blood enters the veins, so as to give to them a degree of dilatation equivalent to their former compression, and which now allows the freedom of contraction in return to the arteries ; without any compression, therefore, of the brain into a lesser space, there is an activity allowed in the vessels.

This motion, communicated through the brain, is very little, nor does it affect the function of the brain ; as we see, when the skull is laid open by wounds, or when the motion is allowed by the fontanelle not being closed. The circulation of the blood in the brain may be obstructed, or it may be accelerated, and by either of these the function of the brain may be affected* : or too much blood may be accumulated within the cranium ; but during this accumulation of the blood there must be a proportional space freed by the absorption of the brain itself, or the partial accumulation in one part of the vascular system of the brain must be accompanied by a deficiency in the other.

OF THE PARTICULAR NERVES.

THE FIRST PAIR OF NERVES ; OR, OLFACTORY NERVES.

We have described the three roots of this pair of nerves : their tri angular form, their bulbous extremities, and their manner of perforating the cribriform plate of the æthmoid bone.

Where the soft and pulpy-like mass of the olfactory nerves perforates the æthmoid bone, the dura mater involves them, and gives them firm coats. There are two sets of nerves thus formed. First, those which pass through the holes in the cribriform plate, nearest the crista galli, run down upon the septum of the nose, under the Schneiderian membrane, and betwixt it and the periosteum ; these become extremely minute as they descend ; and they finally pass into the soft substance of the membrane. The second class of filaments are those which pass down by the outer set of holes of the æthmoid plate, and which are distributed to the membrane investing the spongy bones. Both of these sets of nerves form a considerable net-work or plexus before they are very minutely distributed.†

Although branches of the ophthalmic, palatine, and sub-orbital nerves

* There is much ingenuity wasted on the subject of the circulation of the brain : As the gentle murmuring of a stream, says Lower, lulls to repose, while the mind is disturbed or the imagination awakened by the din of a cataract, so sleep is induced by the gentle flow of the blood in the brain, or is disturbed when the circulation is accelerated. As the fatigue and rest of the body required a variation in the impetus of the blood, the necessary consequence was a variation in the degree of velocity in the circulation and quantity of blood in the head, and this to Lower is the reason of the vicissitude of wakefulness and sleep. The simple fact of the effect of pressure upon the surface of the brain inducing an oppression of the senses has occasioned all their theories of sleep to turn upon this one idea of pressure on the brain.

† Duverney first observed this course and firmness of the olfactory nerves.

pass to the membrane of the nose, they have no power of conveying the impression of odours. These nerves are necessary that the membrane may possess the common sensibility bestowed through the fifth nerve.

Before my discovery that the sensibility of the head and face depended on the fifth nerve, there was much controversy whether or not these additional nerves increased the sensibility of the membrane of the nose to odours.* We find that there pass to the other organs of sense subordinate nerves; and we know that a nerve may be modified to much variety of functions; and this is evident from the nerve of taste being a branch of the fifth pair. But it is doubtful how far a nerve may be capable of receiving at one instant various impressions. Far from considering distinct nerves sent to the same organ as affording an argument for these nerves receiving one uniform impression, and conveying one simple sensation, it would seem more rational to infer that one individual nerve cannot perform two functions, and that two functions are often required in the organs of sense. The olfactory nerve is incapable of bestowing common sensation on the membrane of the nose; the other nerves which ramify on that membrane do, on the other hand, contribute nothing to the sense of smell; we find that the inflammation of the pituitary membrane, which raises the sensibility of the branches of the fifth pair of nerves, does in no degree make those of the olfactory nerve more acute. The membrane is painfully inflamed, but the sense of smell is deadened.

SECOND PAIR; OR, OPTIC NERVES.

In this part of the work there is no occasion to deliver any thing further concerning the optic nerves than has been already said of their origin and final expansion in the retina of the eye. They are uniform in their shape and course, and give off no branches, implying that they are appropriate to a distinct office from the other nerves.

THIRD PAIR OF NERVES; OR, MOTORES OCULORUM.

These nerves have the name of motores oculorum, because they are distributed to the muscles which move the eye-balls. They pass upwards from their origin; and then diverging, they penetrate the dura mater under the extreme point of the tentorium; they descend again by the side of the cavernous sinus; and pass out of the cranium by the foramen lacerum of the sphenoid bone. When this nerve has entered the orbit by the foramen lacerum, it gives out, at the lower and outer part of the optic nerve, a lesser SUPERIOR branch, which is joined by one or two twigs coming from the nasal branch of the fifth pair; and then it crosses the optic nerve to supply the superior rectus muscle of the eye, from which a branch, having perforated that muscle, goes to the levator palpebræ. The trunk of the *third* continues its course under the optic nerve, and nearly at the same place it sends out three branches lying close together. 1. To the inferior rectus, or depressor oculi. 2. To

* John Hunter, Animal Economy, p. 265. Munro, tab. xxiv

the inferior oblique muscle. 3. And to the internal rectus. Or sometimes, varying somewhat, it gives off the first branch to the internal rectus or adductor, another large branch to the depressor, and the continued trunk terminates in the inferior oblique muscle. In tracing the branch which goes to the inferior oblique, we come upon a division of this nerve, which forms the principal root of the ophthalmic, or ciliary, or lenticular ganglion. Haller is of opinion that the ganglion is formed by the third nerve alone, but there is no doubt that a branch of the fifth, viz. of the nasal branch of the ophthalmic division, enters into its composition.

Besides the small ciliary nerves coming from the ganglion, other delicate nerves, both from the third and fifth, pierce the sclerotic coat of the eye. We may more especially notice a twig from the nasal branch of the fifth which goes to the inner part of the eye.

FOURTH PAIR OF NERVES; TROCHLEARES, OR PATHETICI.

These nerves are very small. Their origin, from the superior part of the spinal marrow, and their long course under the base of the brain, have been already described; after proceeding a considerable way, incased in the duplicature of the dura mater, where it forms the extreme point of the tentorium, they pass amongst the lamellæ of the dura mater, where it forms the cavernous sinus. They pass by the outside of the third pair of nerves, turn round so as to be above them, and make their egress through the foramen lacerum of the sphenoid bone. They pass forward in the orbit, undiminished by the giving off of branches; and are each finally distributed to the superior oblique muscle or trochlearis. Sometimes, however, in their course over the cavernous sinus to the orbit, they send branches to unite with the ophthalmic division of the fifth pair; but this is by some anatomists* described as only a close adhesion to the dura mater. My pupils have traced these connections betwixt the fourth and fifth nerves.†

In the part of these volumes which treats of the motions of the eyeball, a reason will be assigned why the origin of the fourth nerve is near the portio dura of the seventh pair, and consequently remote from that of the third.

THE FIFTH NERVE; TRIGEMINUS, OR GRAND SENSITIVE NERVE OF THE HEAD AND MOTOR OF THE JAWS.

The tracing of the branches of the fifth pair, by dissection, is a difficult task; for those branches are distributed among the bones of the face, to the eyes, nose, mouth, tongue, and muscles of the jaws. From this ex-

* Sœmmerring. Winslow. Meckel.

† Sœmmerring, in his plates of the nerves of the eye, represents a twig coming from the frontal branch of the fifth, which unites with the fourth nerve before it enters into the orbit. "4. Quartus cerebri nervus. Prope nervum quintum, nervum tertium et "opticum, transgreditur. et filamenta insigni (*a*) rami primi e nervo quinto auctus in "musculo obliquo superiori diffunditur." Tab. iii. fig. 5. Vieussens also notices the adhesion of the one to the other. In speaking of the 4th he says: "Una cum ramis "minoribus superioribus nervorum quinti paris, quibus incumbunt et adhærent." Vicq d'Azyr mentions the same thing. See Explic. de Planche xvii.

tensive distribution, the fifth nerve is necessarily the largest of those that pass out of the cranium.

It is of a flattened form*: it penetrates the dura mater at the anterior point of the petrous bone, and spreads flat under it. Here, under the dura mater, it is matted into one irregular ganglion; viz. the semilunar, or Gasserian ganglion. This ganglion lies on the anterior point of the temporal, and on the sphenoidal bone. In their passage from the brain, the filaments composing the fifth nerve are loose, or easily separated; at this place they are found so subdivided and entangled as to resist further division. The nerve here swells out into a greater size; it seems to be incorporated with the dense fibres of the dura mater; it becomes of a dark red, or mixed colour, having a semilunar mass of matter of the same appearance as ganglion stretching across it; all which circumstances have by no means been unobserved by anatomists.† Vieussens supposed that the use of this ganglion of the fifth pair, before it perforates the cranium, was to strengthen the nerve, and enable it to withstand the motion of the jaws! Others have said it was a ganglion connecting in sympathy all those parts to which the nerve is finally distributed; and that it was the source of the sympathy which we observe among the muscles of the face.‡

The connection of the Gasserian ganglion with the dura mater is so firm, that it yet remains undecided whether there are sent off here any nerves to that membrane; but I conceive that there are none, and that the connection of the ganglion with the fibrous membrane, or sheath which covers it, has been mistaken for nerves passing from the ganglion to the dura mater.

* So it is said, by Meckel, to resemble the flat worm, or tenia.

† Meckel describes a partition of the dura mater, which separates the fifth nerve from all communication with the cavernous sinus: the sixth nerve, he says, is the only one that really passes through this sinus. This ganglion is termed armilla by Paletta. Scarpa calls it intumescentia ganglio affinis. The following is the description of it by Vieussens: "Gangliofornis autem hujusmodi plexus, crassæ meningis interventu, ossi "petroso utrinque firmiter adhærentis nerveæ fibrillæ, quæ maximam partem, carnosas "fibras referunt simul coalescendo inter se varie colligantur ac implicantur."

‡ "Et affectum animi indicia in faciei partibus depingere adjuvet." Hirsch. Sand. Thes. Diserta. p. 491.

"This ganglion was described and painted by Ridley, An. of the brain, fig. 3. and "Cowper, Ap. to B. fig. 27., but overlooked by most modern anatomists, till of late the "description has been revived by Gasserius and the accurate Dr. Wrisberg, de Quinto "par. Nerv. 1777." Munro on the Nervous System. The figure which Ridley gives is far from being a correct representation of the ganglion. Cowper's drawing is not more accurate. The view given by Munro himself is more correct; but, like the two former anatomists, he has neglected to represent the portion of this nerve which passes the ganglion, although Wrisberg, to whom he refers, has dwelt particularly upon it.

In Eustachius' plates, with the descriptions by Albinus, the fifth is drawn as if it arose by one thick trunk from the brain. Meckel, who gives a most elaborate description of the minute branches of the fifth pair, describes the ganglion, but omits saying any thing of the anterior lesser portion. His description of the ganglion is far from being satisfactory. When the nerve has passed through the oval hole in the dura mater, and is lodged by the side of the sella turcica, it expands, he says, into a flat nerve, resembling a tape-worm (planam tæniam nervosam), which gives off three branches, viz. to the orbit, to the upper, and to the lower jaw. This *tænia nervosa* consists of two separate layers of fibrils, one set being superior to and larger than the others.

The most correct views of this ganglion are to be seen in the plates of Prochaska, de Structura Nervorum, tab. ii. fig. 4, 5, 6.

From the semilunar or Gasserian ganglion, the fifth nerve divides into three great branches; whence the name of trigeminus:

1st, The OPHTHALMIC BRANCH of WILLIS, which passes through the foramen lacerum into the orbit.

2d, The SUPERIOR MAXILLARY NERVE, which passes through the foramen rotundum.

3d, The INFERIOR MAXILLARY NERVE, which passes to the lower jaw, through the foramen ovale.

Such was the description of this nerve, until I found a necessity of examining it more minutely. I then found that Sœmmerring, and others, had observed, that this nerve had two roots, and that one of these roots did not go into the ganglion. Afterwards, upon comparing it with the spinal nerves, I found its correct correspondence to them; and, as I have stated in the introductory view, that it was the superior spinal nerve, corresponding in function, and bestowing upon the head the powers of sensibility and motion, which were given to the body through the spinal nerves.

The ophthalmic and superior maxillary nerves go off from the ganglion of this nerve, and so does a part of the third division. The root or fasciculus, which passes the Gasserian ganglion, joins the third division, and goes out with it through the foramen ovale.*

* Wrisberg described the double roots of the fifth pair, and pointed out the course by which the smallest or the anterior root passes out of the skull. The common trunk of the nerve is subdivided, he says, by means of some small blood-vessels, into two distinct sets of nervous fasciculi, viz. the anterior and the posterior. The latter has accompanying it a small portion of nerve, which descends perpendicularly into the cavernous sinus: it forms no connection whatever with the semilunar ganglion (the Gasserian ganglion,) but passing along it, is finally inserted into the third or inferior maxillary division. He has also given a plate representing the course of the two roots: and he distinguishes the one from the other, thus; P. s. portio ejusdem (quinti paris) superior et anterior: P. i. portio inferior posterior major. When speaking of the mode in which they arise from the brain, he describes a small tract of medullary matter in the pons Varolii, which separates the one root from the other, "lingula quædam pontis, intercedens inter has portiones." Wrisberg, Obs. Anat. de Quinto Nerv. Enc. tom. i. p. 267. Ludwig.

Santorini has also given a very accurate description of the two roots of the fifth pair: "Concerning the origin of this fifth nerve two things are chiefly remarkable; one relating to its origin from the brain, and the other to its mode of passing out of the skull. "The more careful of our anatomists have shown how this nerve can be separated at its "origin into two roots: but it is equally certain that each of these roots arises from a "distinct part of the brain. The larger portion springs from between the transverse "striæ of the tuber annulare: the lesser portion comes from some distance to join with "it. This smaller one seems as if it combined and mingled its fibrils with the larger "one: however, it does no more than merely course alongside of it, being quite separate "and easily detached from it; and when it has arrived within the folds of the dura "mater, it makes a turn inwardly, as if for the purpose of exhibiting how distinct a "nerve it is from the other. The large trunk, after it has pierced the dura mater, is "formed into a plexus; this is not exactly a ganglion, but it resembles rather a net-work "composed of nerves, in which there is also a certain appearance of fleshiness. Up to "this point our smaller fasciculus or root is quite single: it is unconnected either with "the other root or with the plexus that has been described. As soon, however, as it has "passed out of the cranium, then a plexus, which is like a true ganglion, is formed "upon it; and the nerve itself is continued onwards to be distributed principally to "the muscles of the jaw, viz. to the masseter and to the pterygoid."

Girardi, the commentator of Santorini, recommends the roots of the nerve to be floated in water; by this means the distinct fasciculus which passes the plexus or ganglion will be most readily seen: it is altogether whiter, and wants that ruddy appearance which the nerves forming the plexus have. The greater part only of this dis-

THE OPHTHALMIC BRANCH OF THE FIFTH PAIR.

This nerve enters the orbit in three divisions; these are, the *frontal*, the *nasal*, and the *lachrymal* nerves. Immediately after it comes off from the ganglion, while it is yet lying by the side of the sella turcica, the ophthalmic division receives either one or two delicate twigs, which connect it with the sixth pair and the sympathetic. In a preparation before me I see the branch of the sympathetic prolonged by the side of the carotid artery, first attaching itself to the sixth nerve, and then continued onwards

tinct fasciculus passes through the foramen ovale along with the inferior maxillary nerve: some fibrils of it, he thinks, accompany the superior maxillary nerve, and a few join the ophthalmic division. Girardi speaks hesitatingly concerning the ganglion said by Santorini to be formed on this nerve after its exit from the foramen ovale, as if he doubted its existence. Observ. Anat. cap. iii.

It would seem that we owe the discovery of the distinction between the two roots of the fifth to Wrisberg and to Santorini. Pfeffinger says, in speaking of this nerve, "Hoc modo emersus illa planæ tæniæ speciem refert, crassitie æqualem optico nervo, "duobus constantem portionibus, quarum altera posterior simul etiam crassior, altera "vero anterior atque tenuior est: acceptum hoc inventum Santorino atque Wrisber-"gio debemus." Scriptores Neurolog. Ludwig. After the fact was pointed out by these two anatomists we find it noticed by almost every succeeding one. Thus Sœmmerring states in regard to this, "Confirmant vero hasce de duabus nervi quinti portionibus ob-"servationes uno ore neurologici recentiores; v. c. Prochaska, Meyer, Pfeffinger, "Martin, Gunther, Haase, Vicq d'Azyr, Scarpa."

The descriptions and plates of Paletta, Prochaska, and Sœmmerring are, however, the most minute and interesting. They have left nothing in the anatomy of this motor root to be explained. For the account of what Paletta says, see p. 519. Proschaska, in tab. ii. fig. 5, 6. gives this description: "i. Est peculiaris funiculorum nerveorum "sub trunco quinti paris fasciculus, qui communi fere origine cum quinto pari ortus, "sub ganglio semilunari in peculiari impressione in illud ganglion facta decurrit, et qui "quin ganglio per aliquem funiculum connectatur, eo insalutato ad tertium ramum "quinti paris, maxillarem inferiorem dictum, properat, in quem suos funiculos disper-"git. Hic fasciculus confirmare videtur Cl. Wrisbergii et Sœmmerring observationes, "qui quintum par nervorum cerebri in utroque latere duabus portionibus separatis "oriri scripserunt." (De Structura Nervorum.)

Sœmmerring, in his plate of the base of the brain, represents the two origins of this nerve, and he distinguishes them thus: "k. portio ejus anterior minor; l. portio pos-"terior major. Summe autem memorabile videtur secundam vel minorem quinti por-"tionem omnino non immisceri subrubello plexui gangliformi, in quem portio major "dissolvitur, sed fere integram ad ramum tertium abire." tom. ii. § lxi. Ludwig. In his plates of the organs of the senses, we also find him pointing out this distinction between the two roots; in tab. iii. fig. 7, de oculo: "F, portio minor quinti nervi cerebri, "quæ, postquam tuberculum transversum præteriit, ad tertium ramum se confert." Again, in tab. iii.: 11. "portio minor ejusdem nervi quæ intumescentia illi non im-"mixta, tota pœne ad tertium ramum (12.) nervi hujus cerebralis quinti abit." In another of his Works he says, "Omnis minor nervi quinti, plexui gangliformi non "immixta portio, nervum temporalem profundum exteriorem, et nervum musculi buc-"cinatoris maximam partem constituens, tertio huic ramo quinti nervi additur." De Corp. Hum. Fab. But perhaps the most interesting quotation is from the above work, p. 214. of the same volume. After explaining the anatomy of the nerve, he remarks how nearly it resembles the spinal nerves: "Minor nervi (Quinti) pars eandem lati-"tudinem servat, et exceptis nonnullis exterioribus fibris, plexum intrantibus, majorem "portionem descendendo oblique præterit, neque ei fibras addit, (cum fere in modum "quo prior radix nervorum spinæ medullæ ganglion non intrat,) fibras tamen pro-"prias multis modis inter se invicem commiscet. Quo facto, tertio ramo, antequam "foramen calvariæ transit, additur, et ei implicatur, ut quædam tantæ fibræ, ex quo "tertii rami surculo oriantur distincte possint notari." We have formerly seen that this resemblance between the fifth pair and the spinal nerves was observed by Prochaska.

until it falls in distinctly with this branch of the fifth pair.* Before its division, the trunk of this nerve communicates by a small branch with the third nerve, and with the fourth.†

1st, The first of these runs under the periosteum of the upper part of the orbit, and above the levator palpebræ superioris. Upon entering the orbit it gives off a small branch, which passes to the frontal sinus; the nerve then divides into the super-trochlearis, and the proper frontal nerve. The first of these passes to the inner part of the orbicularis oculi and frontal muscle. The other, the outermost, and the proper frontal nerve, passes through the hole, or notch, in the margin of the orbit, and mounts upon the muscles and integuments of the forehead. These superficial branches communicate with the extreme branches of the portio dura or nervus communicans faciei: a circumstance which we have proved to be of the highest interest; since the division of the branches of the fifth deprive the parts of sensibility, whilst the division of the branches of the portio dura deprive the muscles of motion.

Cases are on record, of wounds of the frontal nerve occasioning a great variety of nervous symptoms, and especially loss of sight; and it certainly marks a very particular connection and sympathy betwixt this branch and the common nerves which pass to the eye-ball and iris and the retina, that blindness is actually occasioned by the pricking of the frontal nerve. Morgagni supposes this to be occasioned by the spasmodic action of the recti muscles pressing the globe of the eye down against the optic nerve.

2. The NASAL BRANCH of the ophthalmic nerve sends off a slip or twig to form, with a branch of the third pair, the LENTICULAR, or OPHTHALMIC GANGLION‡; while the trunk of the nerve passes obliquely forwards, under the attollens palpebræ, and levator oculi, and it supplies a twig which joins with that branch of the third nerve which is distributed to these muscles.§ While pursuing its course along the inside of the optic nerve, it gives off one or two extremely small twigs, which

* Meckel, in his Treatise on the fifth pair, inveighs strongly against all anatomists who say that the fifth has any other connections with the sympathetic than through the means of the Videan nerve: and he adds, if any branches, such as are described exist, it must be in the imaginations of those who pretend to have seen them. He appeals to the writings of Eustachius, Haller, Albinus, and Morgagni, who do not make any mention of these nerves. On the other hand, Willis, Ridley, Vieussens, Cowper, Winslow, and others, have both represented them in their plates, and described them very accurately. See Willisii Opera, cap. xxii. fig. 1. lit. A. b. b. Ridley, Anat. of the Brain.

† Prochaska, in plate ii. fig. 1. represents a branch communicating between the ophthalmic division of the fifth and the third nerve—" d. est funiculus a ramo nervi " ophthalmici ad ramum unum tertii paris cerebri accedens." Sœmmerring, in describing the course of the ophthalmic branch, notices the connection that it has with the nerves in its neighbourhood: " Primus ramus quinti nervi aliquot lineas ad hiatum " orbitæ superiorem adscendit, deorsum cum tertio nervo sursum cum quarto, ad in- " teriora vero cum sexto nervo per telam cellulosam, nonnunquam vero cum quarto " nervo per insignem surculum, transverse incedentem conjungitur." De Human. Corp. Fab. tom. iv. Vieussens, lib. iii. p. 161. tab. xxii. xxiii. Cowper's Anat. tab. vi. fig. 26. Winslow Transl. by Douglas, pp. 80. 121. vol. ii.

‡ Vieussens describes delicate twigs which are distributed on the inferior rectus and the adducens muscles before this lenticular branch is given off. *Fig.* xxii. *lct. g. h. i. i.*

§ Sœmmerring. Fasc. de Oculo. tab. iii. fig. 6. r. b. w. and fig. 7. u. Prochaska.

join the fasciculi of ciliary nerves coming off from the ganglion. The nasal branch then continues its course betwixt the superior oblique and adductor muscles; before piercing the orbital plate, it sends forward a branch, which, passing under the pulley of the superior oblique muscle, joins that division of the frontal nerve which passes over the pulley. This branch supplies the caruncula lachrymalis, and sends a twig down to the lachrymal sac and duct. It emerges from the orbit superficial to the tendon of the orbicularis oculi, and unites with the branches of the portio dura, and of the infra-orbital branch of the fifth. The proper nasal nerve passes through the foramen orbitarium anterius, enters the skull again, and lies on the cribriform plate of the æthmoid bone under the dura mater. It passes through one of the anterior holes of the cribriform plate, and gives branches to the frontal sinuses. After having continued its course in a groove on the nasal process of the frontal bone, it runs forward and downward in a similar groove on the inside of the os nasi; from thence, getting on the outside of the cavity of the nose, it runs along the cartilaginous part of the ala, and near the extremity of the nose mounts upon the tip of the ala, and then, dipping down between the two alæ, is lost on the anterior extremity of the cartilaginous septum. In its course it sends several small filaments into the alæ. It bestows common sensibility to the membrane of the nose, while the sensibility to odours belongs to the first nerve.*

We observe such a connection of the nerves of the eye and nose, and of those distributed to the inner angle of the eye, and muscles of the eye-lids, as sufficiently accounts for the sympathy existing among those parts. We see the necessity of this connection, since the excitement of the glands which secrete the tears, the action of the muscles, and the absorption of the tears into the nose, must constitute one action; nevertheless this motion of the muscles, when the surfaces are excited, results from the connection of the nerves (the fifth and seventh) in the brain, as might be easily shown. Willis describes a nerve going off from the nasal branch to the retractor oculi in brutes.

The LENTICULAR, or, OPHTHALMIC GANGLION, comes again to be considered under this division of the fifth pair. It is formed by a twig from the nasal branch of the fifth pair, and a division of the third pair of nerves. The ganglion is of a square form, and is situated upon the outside of the optic nerve. The ciliary nerves pass out from this ganglion in two fasciculi; they are ten or twelve in number; they are joined by branches of the continued nasal nerve. The ciliary nerves run forward, amongst the fat of the orbit, to the sclerotic coat of the eye, and pierce it very obliquely in conjunction with the ciliary arteries. The ciliary nerves and arteries then pass forward betwixt the sclerotic and choroid coats of the eye to the iris. The iris is considered as the part the most plentifully supplied with nerves (as it certainly is also with arteries) of any part in the body. It follows, indeed, from what we formerly said, that a profuse circulation of blood is necessary to an accumulated nervous power. The fine sensibility and mobility enjoyed by the iris is owing to those nerves: the fifth nerve giving sensibility, and the third mobility.

* See John Hunter, Animal Economy. Monro, tab. xxiv.

From the connection of these ciliary nerves with those passing to the nose, Sœmmerring accounts for sneezing being the consequence of a strong light upon the eye. This may perhaps be true; but certainly the temporary loss of sight from sneezing does not depend upon this connection of the nerves, but upon the immediate affection of the optic nerve and retina, from the concussion and interruption to the circulation, or from the accumulation of blood in the eye.

2. The LACHRYMAL NERVE is the least of the three divisions of the ophthalmic nerve: it divides into several branches before and after it has entered the gland.* Several of these branches pass on to the tunica conjunctiva, being joined by a twig of the first branch of the superior maxillary nerve. Others connect themselves with the extremities of the portio dura of the seventh pair, and with the superior maxillary nerves. By these the flow of the tears is commanded by the degree of irritation of the surface of the eye, so that the tears flowing wash away the offending matter. I have had several cases communicated to me of total insensibility of the surface of the eye, while the motion and sensibility to light remained entire. In all these instances I had reason to attribute the defect to the injury of the fifth nerve.

THE SECOND BRANCH OF THE FIFTH PAIR; VIZ. THE SUPERIOR MAXILLARY NERVE.†

The superior maxillary nerve, the middle one of the three divisions of the fifth, having passed the foramen rotundum, emerges behind the antrum Highmorianum, at the back part of the orbit, and near the root of the pterygoid process of the sphenoid bone. The infra-orbital canal lies directly opposite, and ready to receive one branch, while the spheno-maxillary opening is ready to receive another. Here several small branches go off, the *Rami molles medullares*, and render the dissection difficult.‡ The chief part or trunk of the nerve may be said to be seated, and to give out its divisions, in the pterygo-palatine fossa. Through the spheno-maxillary fissure a branch of the superior nerve is sent into the socket of the eye. This twig unites with branches of the lachrymal nerve, and in general supplies the periosteum of the orbit. It then sends through the foramen in the os malæ, a branch which is distributed to the orbicularis muscle of the eye-lid, and to the skin of the cheek, viz. *subcutaneus malæ*. Another branch of this division passes upward from the zygomatic fossa, in a groove of the wing of the sphenoid bone, to the temporal muscle, and getting superficial, it accompanies the branches of the temporal artery. Here it becomes superficial, forming the *subcutaneus temporalis*.

The superior maxillary nerve, after sending off these branches, divides into four branches: 1. *Vidianus*; 2. *Palatinus*; 3. *Alveolaris*; whilst the continued nerve is, 4. *Infra-orbitalis*.

The VIDIAN nerve sends off branches which enter the nares, and ex-

* Vieussens, Haller, and Meckel take notice of small delicate nerves which are the continuation of the nerves of the lachrymal gland, and can be traced to the tunica adnata. Although they observe some anatomists have considered these to be the ducts of the lachrymal gland.

† According to Winslow. ‡ Meckel, de Quinto pare. lviii.

tend betwixt the mucous membrane and periosteum to the æthmoid and spongy bones. These are divided into the *nasales superiores anteriores et posteriores.* Where the Vidian nerve parts from the trunk, the *spheno-palatine ganglion* is formed*; and having sent these nasal branches off, it enters the foramen pterygoideum and runs backwards. Here it splits: one branch, after a long retrograde course, enters the Vidian hole of the petrous part of the temporal bone, and forms a connection with the portio dura; while the other, in the carotid canal, forms a connection with the great sympathetic nerve, by joining the branches of the fifth and sixth pair, which pass down with the carotid artery. In the manner of joining of the sixth, the Vidian and the sympathetic in the carotid canal, and around the carotid artery, a considerable variety occurs. It is, in fact, a union of the fifth, sixth, and seventh with the ascending visceral nerve.

The *superior posterior* nerves of the nose come off from the Vidian just when it has entered within its canal.

The Palatine nerve is the largest of the branches sent out from the spheno-palatine ganglion. Before it descends it gives off small nerves called *anterior superior internal*, which ascend to the superior spongy bone, and join with the posterior branches of the olfactory nerves.

The palatine nerve next gives off the *naso-palatine*, described by John Hunter and Scarpa. This nerve, bending upon the superior part of the vomer, and coursing in an oblique manner towards the anterior and lower part of the vomer, pierces the foramen incisivum,† and is lost in the gum, behind the incisor tooth, and on the membrane of the roof of the mouth at that part.

We have to recollect that there are two canals in the palatine bone, conveying nerves to the palate: one, the anterior and larger; another, running nearly parallel to it, which is smaller. The division of the palatine nerve, descending at first along the spheno-palatine canal, which leads to the palatine foramen, gives off the *inferior internal* nerves of the nose, which are distributed principally on the upper and lower turbinated bones. Continuing its course along the canal, it sends off a branch to the tonsils, which descends before the pterygoid processes and betwixt the maxillary and palatine bones, and is called the *palatinus minimus exterior.* A small nerve descends through that foramen, which is immediately anterior to the pterygoid process, to supply the circumflexus, levator palati, and azygos uvulæ.‡ While the larger branch descends through the greater and more anterior foramen, and divides into three branches, which supply the soft parts lining the palatine bone, and the palatine plate of the maxillary bone; also the arches of the palate. A groove in the bone points out the course of this nerve forwards.

The superior maxillary nerve, after sending off the branches which form the spheno-palatine ganglion, passes obliquely downward

* Meckel de Ganglio Secundi Rami Quinti Paris nuper detecto. Histoire de l'Acad. Roy. des Sciences, Année 1749, à Berlin 1751, p. 84.

† In the fœtus, the foramen innominatum, or vidian hole, is so short, that the union of the vidian nerve and portio dura may be seen. In the adult it is seldom necessary to cut more than the tenth of an inch to expose clearly the union of the nerves. See John Hunter, Animal Economy, p. 266.

‡ I am of opinion that these muscular nerves may in part be ramifications of the portio dura, coming along the vidian foramen.

to the infra-orbital canal. In this course it gives off the posterior nerve to the teeth of the upper jaw ; and this again gives off a twig, which takes a course on the outside of the maxillary bone, and supplies the gums and alveoli, and buccinator muscle.

Before entering the canal it sends off the ALVEOLAR branch, which supplies the molares, through the foramina, on the posterior surface of the maxillary bone, and then follow the alveolar branches of the internal maxillary artery ; a branch from this division enters the buccinator muscle.

While passing in its canal, the INFRA-ORBITAL nerve gives off the anterior nerves to the teeth ; and when it emerges from the infra-orbital foramen, it spreads widely, and, forming a plexus, enters the muscles of the lip and nose, goes on to the integuments ; and here it is of course joined by the appropriate division of the portio dura, connecting itself with the extremities of the portio dura of the seventh pair or nervus communicans facialis.

The "tic dolouroux," and the "tic convulsif,*" of the French authors, are diseases attributed to the affection of this nerve. The seat of the tic dolouroux is the side of the face, the nostril, the cheek-bone, and root of the alveoli. Sauvage calls it the trismus dolorificus, or maxillaris. But it is a disease not absolutely fixed to this joint of the cheek-bone ; but on the contrary, from the universal connection betwixt the nerves of the face, it takes, sometimes, a wide range ; however, I attribute it to the influence of the sympathetic nerve, and conceive that this is the reason that the disease is so often seated in this superior maxillary nerve, which has the most direct connections with the sympathetic.

It is a disease attended with extreme pain, which forces the patient to to cry out in great agony. The patient has described it to me as like a flash of lightning through the head, so sudden is it in its attack. And as to its violence, it is sufficient to say, that it throws the same patient into the most violent contortions of pain, who will sit unmoved and suffer the nerve to be deliberately cut across. The pain is felt deep rooted in the bones of the face, and seems to spread upon the expanding extremities of the nerve ; it is sudden, violent, and reiterated in its attack, and it varies in the length and repetition of its accession.

This disease is apt to be confounded with the affection of the antrum Highmorianum, the tooth-ach, rheumatism, and clavis hystericus, or even with venereal pains.

In hemicrania, the affection of the three branches of the fifth nerve is such as to mark their distributions. There is swelling and pain of the face, pain in the upper maxillary bone, pains in the ear and in the teeth, difficulty of swallowing, and, lastly, stiffness in moving the lower jaw. I have shown that the muscular branches of the fifth belong to mastication and the motion of the jaw ; the stiffness of the jaw therefore may result from the affection of the fifth.

There are cases spoken of by Sabbatier, where this infra-orbital nerve being wounded, unusual nervous affections, and even death, were the

* With respect to the convulsive motions of the face, since the discovery that the actions of the muscles of the face depend entirely upon the portio dura, these authorities must be wrong who attribute the convulsive motions of the face to the fifth pair.

consequence : but it would rather appear that, independently altogether of the affection of the nerves of the face, inflammation spreading from the wound to the brain had, in the examples which he gives, been the occasion of the unusual symptoms, and of the death of the patients.

THIRD BRANCH OF THE FIFTH PAIR; OR, LOWER MAXILLARY NERVE.

This, the last of the three great divisions of the fifth pair of nerves, the largest but the shortest branch within the skull, passes out by the foramen ovale.* It is distributed to the muscles of the lower jaw, tongue, the glands, and skin.

On instituting the comparison betwixt the spinal nerves and the fifth, I observed that a fasciculus passed the Gasserian ganglion and joined the third division, and passed with it through the foramen ovale. Having followed it thus far, I put my pupils on the further prosecution of this branch, to determine whether the peculiarity of this division was owing to its being the gustatory, or a muscular branch. I could, upon their authority, show, that this was the motor portion of the fifth nerve, and that it went to the muscles of the jaw and cheek. But at the same time I consulted books, and I found a very minute description of it.

Santorini and Wrisberg first accurately described the course of this root. Paletta† also noticed it, but he viewed it as a distinct and newly discovered nerve. He traced it from its origin along the inside of the proper fifth, past the ganglion, and into the foramen ovale. When they have passed together through the bone, filaments from that portion of the nerve which has a ganglion, unite with this newly discovered accessory trunk ,and form a plexus with it. But I may just observe, that if we were to admit this to be a new nerve, we might so distinguish the anterior roots of all the spinal nerves, since this division is to the fifth what the anterior division is to the proper spinal nerves.‡ Observing this (anterior) division of the fifth narrowly, Paletta finds it consisting of two principal nerves : 1. *Fasciculus primus, seu nervus crotaphiticus.* 2. *Fasciculus secundus, seu nervus buccinatorius.* Tracing them on their course he finds them passing, as their names imply, into the temporal and buccinator muscles. The First of these gives off the *nervus massetericus.* The ramus massetericus, passing betwixt the external pterygoid and temporal muscles, and over the semilunar notch of the lower maxillary bone, and behind the tendon of the temporal muscle, sinks into the masseter. This nerve also gives off the two temporal nerves, which are named *temporalis profundus exterior* and *temporalis profundus interior.*§ The Second

* The lower maxillary nerve of Winslow ; gustatory of Meckel ; Ramus major posterior nervi quinti paris, Vieussenii.

† J. B. Paletta de nervis Crotaphitico et Buccinatorio, 1784. Mediolani. Ludwig. tom. iii. p. 63.

‡ This objection was urged by Sœmmerring. " Cl. Paletta ramos quinti paris crotaphiticum et buccinatorium pro peculiaribus paribus habet. Sedula autem in hanc " rem inquisitione numquam istos ramos adeo sejunctos inveni a ramo tertii nervi " quinti paris, ut integri separari queant. Quodsi hæc divisio admittenda esset potiore " profecto jure radix anterior cujusvis nervi spinalis segreganda esset a posteriori, ad " peculiare par constituendum." Sœmmerring de Corp. Hum. Fab. vol. iv. p. 125.

§ A branch of the temporalis profundus enters the orbit and joins the lachrymal nerve.

of these, or the buccinatorius, supplies the pterygoideus externus, and gives some twigs to the temporal muscle. It then supplies the buccinator muscle, the glandulæ buccales, and a few delicate nerves upon the cheek unite with the branches of the portio dura, and supply the levator anguli oris, triangularis and orbicularis. The nervus buccinatorius gives off the ramus pterygoideus, which is a small branch going to the pterygoideus internus, and circumflexus palati. In short, tracing this division of the maxillary nerve in all its course, he finds it exclusively given to the muscles of the jaw and cheek.* But a circumstance occurs here not without interest: before entering the muscles, these branches are joined by branches of the ganglionic portion of the nerve, (which he persists in calling the maxillary nerve, in contradistinction to his supposed discovery of the new nerve.)†

When we compare the distribution of the nerves to the muscles of the jaws and cheek, with the distribution of the seventh pair and the fifth pair to the external muscles of the face, and when we take into consideration that the division of the seventh nerve cuts off all power of moving the muscles of the face, a question may very naturally occur. If dividing the muscular nerves is attended with loss of motion in the muscle, what is the use of the sensitive nerves which are given to these same muscles, seeing they confer no power of motion ?‡

We now attend more particularly to the two greater divisions of this nerve, after the nerve has passed the pterygoid muscles, viz. the proper

* Meckel, in his description of the third division of the 5th pair, follows Eustachius and Albinus in subdividing this nerve into two distinct sets of branches. When it has passed through the foramen ovale it is divided into two portions, the Anterior and Posterior branches, or, as Meckel describes them, the Superior and Inferior. The former split at once into many separate branches, while the latter, the larger nerve, forms the continued descending portion of this third division. Meckel enumerates as belonging to the SUPERIOR RAMUS, 1. The Massetericus. 2. Temporalis profundus exterior. 3. Temporalis profundus interior. 4. Buccinatorius. 5. Pterygoideus. The latter, or INFERIOR RAMUS, after giving off branches to join those of the SUPERIOR, is composed of three principal branches: 1. Maxillaris inferior. 2. Lingualis seu gustatorius. 3. Temporalis superficialis. See Meckel, de Quinto Pare Nervorum. Sect. v. tom. 1. Ludwig.

† It is interesting now to find, that Paletta suggested what I have proved to be true, —that the anterior portion of the fifth pair bestowed voluntary motion on the muscles of the jaw. Speaking of the *nervi crotaphitici et buccinatorii* he says, "illud tamen "videtur certum præcipuam eorum actionem esse in partes a voluntate motas: quum "rami inserantur in musculos temporalem, masseterem, buccinatorem, labiales et pterygoideos, quorum præcipue voluntariis maxillæ inferioris famulantur." He even supposes that trismus is an affection of this nerve. He confesses, however, that he cannot understand what may be the function of the other division of this nerve, or why it should differ from the other in having a ganglion upon it. This difference will always, he says, be a source of obscurity in studying the functions of these two divisions. And it may here be observed, that proceeding in the same course as Paletta did, it was impossible for the ingenuity of man to discover the true functions of the two roots of this nerve. Paletta was convinced that the anterior division was a motor nerve, because he saw that it was distributed to muscles: but by the same reasoning he must have also inferred that the posterior portion, which has the ganglion upon it, was in like manner for bestowing motion, since he must have seen that it was distributed freely to the muscles. My conclusive experiments were suggested by my views of the spinal nerves.

‡ This is the first idea which suggested the paper in the Transactions of the Royal Society, entitled "On the Nervous Circle which connects the Voluntary Muscles with the Brain."

maxillary nerve which passes into the lower jaw, and the gustatory or lingual nerve. Close to the junction of the anterior with the posterior root two branches come off, which run in a parallel direction towards the condyle of the jaw: they unite and then give off branches; two of these, or sometimes three, combine with the portio dura when it is passing over the ramus of the jaw-bone—another goes to supply the outer ear, and a considerable branch passes upwards to the temple; this is the nervus temporalis superficialis, seu auricularis. There is a nerve arising nearly from the same part, but a little lower, which passes down alongside of the maxillary nerve; it leaves this nerve when about to enter into the foramen in the lower jaw-bone, and is finally distributed to the mylo-hyoideus and anterior portion of the digastric muscle, which open the mouth by drawing down the jaw.

The GUSTATORY NERVE is the division which descends to the tongue. Immediately after its separation from the nerve of the lower-jaw, it is joined by the *chorda tympani*; or, perhaps, we should rather say, a branch of this nerve, by traversing the petrous portion of the temporal bone in a retrograde direction, unites itself with the portio dura of the seventh pair, as it is passing through the ear. This nerve being seen passing across the tympanum is the reason that it is called CHORDA TYMPANI. It is commonly described as going along the Eustachian tube; we ought rather to say, in the groove of the bone under that passage. Arriving in the cavity of the tympanum, it runs across, and joins the portio dura before its exit by the stylomastoid foramen. The gustatory nerve, proceeding obliquely downward, sends off twigs to the salivary glands and muscles, situated betwixt the jaw-bone and tongue. Where it is passing by the side of the sublingual gland, it gives out some filaments which form a small GANGLION, from which branches penetrate the submaxillary and sublingual glands. The trunk then proceeds onward betwixt the sublingual gland and the musculus hyo-glossus; several twigs are sent off, which form a kind of plexus amongst the muscles and salivary glands*; and, communicating with the ninth pair of nerves, are distributed, finally, to the gums and membrane of the mouth.

The gustatory nerve terminates in a lash of nerves, which sink deep into the substance of the tongue, betwixt the insertion of the stylo and genio-glossal muscles. These pass to the papillæ on the tip and edges of the tongue. The sense of taste, the impression of which is received upon this nerve, is seated in the edge and anterior part of the tongue.

The proper lower maxillary nerve, which enters into the lower jawbone, sometimes called *mandibulo-labralis*, passes downward in an oblique direction to the groove of the lower jaw-bone. Before this nerve enters the canal of the bone, that nerve passes off which is distributed to the muscles which open the mouth by drawing down the jaw: viz. the mylo-hyoideus and digastricus. The nerve then entering the bone, runs its course all the length of the lower jaw within the bone, and comes out at the mental hole. In this course it gives branches which enter the roots of the teeth, and accompany the branches of the arteries. When this lower maxillary nerve has escaped from the mental hole, it divides into two branches upon the chin; one of these is distributed to

* Plexus gangliformis. Scarpa.

the obicularis and depressor angulioris, and to the skin and glands of the lips; the other to the depressor labii inferioris and integuments, and forms a kind of plexus, which surrounds the lips. These nerves are also connected with the wide spreading branches of the portio dura of the seventh pair; and they are the lowest branches of the facial nerves, and the last enumerated of the intricate branches of the fifth pair.

In recapitulating the branches of the fifth nerve, it is only necessary to say, that it goes every where to the head and face, externally and internally; that it is universally the nerve of common sensibility; that it possesses also some peculiar sensibilities, being the gustatory nerve, and also giving peculiar sensibility to the surface of the eye; finally, that it is the nerve of the muscles of the jaw. On exciting the root of the fifth pair of an ass recently killed, the jaws were made to snap violently; and on dividing the fifth in another ass, the jaw fell down, the muscles being incapable of closing the jaw. On attempting to excite the muscles of the eye by galvanism sent through the fifth pair, the muscles of the jaw only were affected.

Professor Boch of Leipsic, and M. Cloquet of Paris, in prosecuting the minute anatomy of the sympathetic nerve, have described a small ganglion lying on the carotid artery, where it has just entered within the skull. This my pupils have frequently shown to me, and we find it described by Willis.* From the dissection of those nerves, in the larger animals, it appears quite an error to suppose that the principal connection between the nerves of the head and the sympathetic is through the sixth pair. For this small ganglion is a centre from which nerves can be traced to the ophthalmic division of the fifth, the sixth, and the sympathetic.†

THE SIXTH PAIR OF NERVES; ABDUCENTES, OR MOTORES EXTERNI.

The nerve of the sixth pair, as we have seen, arises betwixt the tuber annulare and the corpus pyramidale. Advancing forwards and upwards, sometimes above and sometimes beneath the branches of the basilar artery, it penetrates the dura mater by the side of the basilar sinuses. It then passes by the side of the carotid artery, and through the cavernous sinus. Here it gives off filaments, which, clinging to the carotid artery, descend with it until they are joined by a branch of the Fifth Pair. These together form what was formerly considered the origin of the great sympathetic nerve. It has been disputed whether a branch is given out from, or received into, the sixth nerve; and in the description of the sixth pair, we might say, with reason, that as it passes the carotid artery, it receives one or more nerves which come up through the carotid hole, and encircle the artery.‡ The sixth nerve enters the

* Alter superior idemque major Paris quinti ramus, sub dura matre juxta sellæ turcicæ latus aliquanto spatio recta incedit: atque è regione Glandulæ pituitariæ carotidis trunco propagines quasdam elargitur dein nervo sexti Paris inosculatur: et exinde surculum, modo unum, modo duos remittit, qui cum surculo altero, a nervo sexti Paris reflexo, uniti, nervi intercostalis radicem, sive caudicem primum constituunt. Willisii Opera Omnia, cap. xxii. fig. 1., lit. A. *b.b.*

† The anatomy and physiology of the third division of the fifth nerve are fully treated of in a paper of the Author's, sent, in the present session, to the Royal Society.

‡ Prochaska hesitates to say whether the sixth pair gives off the sympathetic nerve

orbit by the foramen lacerum, with the third and fourth nerves and first branch of the fifth. It pierces the abductor muscle of the eye before it is finally distributed to its substance.

It is with particular pleasure that I have here to refer again to our celebrated countryman, Willis, whose minute knowledge of anatomy cannot be sufficiently admired. He describes a branch of this sixth nerve going to the retractor oculi of brutes. When we consider the office of the retractor oculi to be the protrusion of the *haw*, it suggests to us a reason why the sixth nerve should go to the external rectus: for the direction of that muscle is such, that in its action it must draw the eye-ball towards the os planum, and assist the retractor oculi in thrusting out the haw. If it be said, what then is its use in the human eye? we may allege, that it is for the same purpose; that is, to draw the eye when painfully excited towards the os planum, and so thrust out the semilunar fold and caruncula lacrymalis. In matter of fact, the caruncula and membrane are thrust out, however we may explain it; for if the eyelids be kept forcibly apart, and an attempt be made to wink, as if a mote were in the eye, the membrana semilunaris and caruncula lacrymalis are brought forward over the eye so as to make no bad representation of the haw. Sœmmerring describes the sixth arising in two roots, an external and an internal portion. Vicq d'Azyr and Scarpa describe an external larger and internal smaller portion constituting the roots of this nerve.

It has been presumed that the sixth nerve does not give off the sympathetic nerve, but receives those branches from it, because the sixth nerve is larger betwixt this point and its distribution in the orbit, than betwixt the same point and its origin from the brain. But I conceive, that this enlargement of the sixth pair is not altogether owing to such a junction; but that, on the contrary, the nerve naturally swells out when it enters the sinus, not from being soaked in the blood of the sinus, but from its having additional investing coats, or from the coats being strengthened in order to prepare the nerve for its passage through the sinus.

Again, that the sympathetic nerve sends up those branches to join the sixth, has been presumed from the effects of experiments on brutes in which the sympathetic nerve has been cut or bruised. Inflammation and heaviness of the eye has been observed to result from these experiments. This would infer a relation with the fifth rather than with the sixth.

We shall probably cease to dispute this point, when we consider the relations and use of the sympathetic nerve.

as one of its branches, or the sympathetic only forms a connection with the sixth. Yet in describing tab. ii. fig. 5, 6, De Structura Nervorum, he points out two twigs, an anterior and a posterior one, which join the sympathetic and the sixth pair, and he remarks that the sixth becomes a little thicker after this junction. Sœmmerring is more decided in giving it as his opinion that the sympathetic sends up these twigs to be added to the sixth pair: "Nervo sympathetico surculum istum non præbere sed ab illo accipere satis patet, partem enim inter, qua surculus adest, et musculi oculi abductorem "crassior videtur quam pone dictant partem, quod surculo nervi petitoque augeri demon-"strat. Alius autem color est et habitus nervi sexti: fila enim nervi sexti duriora sunt, "fusciora, minusque perlucida filis sympathetici nervi. Vagina etiam nervus sextus "cinctus, extra quam filum nervi sympathetici accedit." Sœmmerring, Fab. Hum. Corp. tom. iv.

The sympathetic nerve may be defined, a tract of medullary matter, passing through and connecting the head and neck, the viscera of the thorax, abdomen, and pelvis, into one whole. The sympathetic nerve is singular in this, that it takes no particular origin, but has innumerable origins, and a universal connection with the other nerves through all the trunk of the body. Many of the viscera to which it is distributed are entirely independent of the will, and have functions to perform too essential to life to be left under the influence of the will. The sympathetic nerve may be thus, as it were, a system within itself, having operations to perform of which the mind is not conscious; whilst the extent of its connections occasion, both in health and disease, sympathetic affections not easily traced.

It is impossible seriously to consider the sixth nerve as giving the origin to the sympathetic in any other light than as such an expression may be subservient to arrangement, description, and general enumeration of the nerves; — a thing most necessary in so intricate a piece of anatomy. The character of the sympathetic nerve (or, I believe I should say, sympathetic system of nerves,) is that of having ganglions formed upon it; — and thus the ganglions in the sockets of the eyes, in the fossæ of the jaws, and every where, whether within or without the head, are to me proofs of the sympathetic nerve extending its connections to such parts.

OF THE SEVENTH PAIR OF NERVES.

The nerves of the seventh pair consist each of two fasciculi, which arise together, and pass into the foramen auditorium internum.* But these portions do not pass through the bone in union; for the anterior and lesser fasciculus is a muscular nerve, which passes through to the face, and is invested, like the common nerves of the body, with strong coats. It is therefore called the PORTIO DURA.† The more posterior fasciculus is the auditory nerve, and is distributed to the organ within the pars petrosa of the temporal bone; and in distinction it is called the PORTIO MOLLIS.

The PORTIO DURA, OR NERVUS COMMUNICANS FACIALIS, OR RESPIRATORY NERVE OF THE FACE. This is the grand motor and respiratory nerve of the face. When divided all motions but those of the jaws cease, and more especially all consent of the muscles of the face with the actions of respiration are cut off by the loss of this nerve. The portio dura, in passing from the brain to the internal auditory foramen, is lodged in the fore part of the auditory nerve, as in a groove. When it leaves the auditory nerve, it passes on through the bone, and emerges on the side of the face through the stylomastoid foramen at the root of the styloid process, so as to come out betwixt the lower jaw and the ear, covered, of course, by the parotid gland. The portio dura, while

* The intermediate filaments of Wrisberg, which are betwixt these two portions of the seventh nerve, are afterwards united to the portio dura, and must be considered as one of its roots.

† Galen divided all the nerves of the brain into those two classes, *mollis* and *dura*; of which the first were those of the senses, the latter the motores corporis.

passing through the canal of the temporal bone (which is the aqueduct of Fallopius), gives off a branch which unites with the Vidian nerve of the fifth pair: or rather, we may conclude with the best authors, that it receives a branch which comes retrograde from the vidian nerve, passing through the small hole on the anterior surface of the petrous part of the temporal bone. The portio dura, when it has proceeded onwards by the side of the tympanum, gives off one or more very minute branches to the muscles within the tympanum, which give motion to the small bones of the ear. A little further on, this nerve gives off a more remarkable branch, which, passing across the tympanum, is called CHORDA TYMPANI. This is the branch, which, as we formerly mentioned, joins the gustatory branch of the lower maxillary nerve. The chorda tympani passes into the tympanum by the hole in the pyramid: it takes its course on the membrane betwixt the long process of the incus and the handle of the malleus; it is then received into a groove of the bone; it passes by the side of the Eustachian tube; and, after enlarging considerably, it is united with the gustatory nerve, as described.

When the portio dura has escaped from the stylo-mastoid foramen, but is yet behind the condyle of the lower jaw, and under the parotid gland, it gives off, 1st, The posterior auris. This has connection with the first cervical nerve, and passing up behind the ear, it is connected with the occipital branches of the third cervical nerve. 2d, The nervus stylo-hyoideus to the styloid muscles, and here it unites with the sympathetic. 3d, A branch which supplies the deep muscles, and joins the laryngeal branch of the eighth pair.

The portio dura, rising through the parotid gland, spreads out in three great divisions; and, where it divides, the membranes connecting the divisions are like webs between the toes, and this has acquired for this division the name *pes anserinus*. Here it is joined by branches of the third division of the fifth nerve, and a sort of plexus is formed, so that ansæ or rings characterise this part of the nerve.

1. An ASCENDING BRANCH divides into three temporal or jugal nerves; so called, because they ascend upon the jugum, or zygomatic process, to the occipito-frontalis muscle. Two orbitary nerves, which, passing up to the orbicularis muscle, branch upon it and inosculate with the extremities of the fifth pair. A small nerve enters the orbit by foramina in the malar bone. These branches of the portio dura to the muscles of the eye-lids are the sole movers of the muscles here; and if they be destroyed by tumor, abscess, or the knife, the eye-lids remain open and the eye-ball exposed.

2. The SUPERIOR FACIAL division of this nerve passes out from the upper part of the parotid gland, across the face, to the cheek and orbicularis muscle of the eye. The MIDDLE FACIAL NERVE passes from under the risorius Santorini; it goes under the zygomatic muscle, and encircles the facial vein; it sends branches forward to the muscles of the nostril, to the lips, and upwards to the eye-lids, and to unite with the infra-orbital nerve. Its branches join the buccinatorius or masticatory division of the fifth nerve. There is AN INFERIOR FACIAL NERVE, which comes out from the lower part of the parotid gland, passes over the angle of the jaw, and is distributed to those fibres of the platysma myoides which stretch up upon the face, and to the risorius Santorini: it

passes on to the angle of the lips, and is distributed to their depressor muscle. Betwixt those facial nerves there are frequent communications, while they are at the same time united with the extremities of several branches of the fifth pair before piercing the substance of the muscles.

3. The DESCENDING BRANCHES pass along the margin of the jaw, down upon the neck, and backward upon the occiput. Thus we see that the portio dura is well named the communicating nerve of the face. It is distributed to the side of the face, head, and upper part of the neck: it unites its extreme branches with those of the three great divisions of the fifth pair, with the eighth and ninth, with the accessory of the eighth pair, with the second and third cervical nerves, and with the sympathetic. From those various connections the portio dura has also been called the *lesser sympathetic.* The connection of the nerves of the face, throat, and neck, with the nerves of respiration, affords one of the most curious subjects of inquiry as connected with expression.*

(The PORTIO MOLLIS of the seventh pair of nerves is the acoustic or auditory nerve, which shall be considered in a more particular manner when we describe the organ of hearing.)

In the Appendix to the new edition of the Exposition of the System of the Nerves, the reader will find abundant cases demonstrative of the truth of the author's opinions. In the time that has elapsed since the appearance of the papers in the Transactions of the Royal Society, the consultations on this subject have so multiplied, as to enable him to give cases of injuries both of the seventh and fifth nerve, and also of diseases of these nerves, which leave nothing to be desired for proving their distinct uses.

[FURTHER ILLUSTRATION OF THE FUNCTIONS OF THE NERVES OF THE FACE AND HEAD.

I shall add here some familiar instances and cases to show the importance of the knowledge of the nerves of the face in the investigation of disease. The reader has only to take with him these facts; 1. The branches of the fifth nerve bestow sensibility to the head and face: 2. The same nerve supplies the muscles of the jaws for mastication: 3. The portio dura is the muscular nerve of the face, it combines the muscles with the acts of respiration, and is the source of all expression in the face.

"*J. Richardson*, October, 1820.—On first looking at this man, there does not appear to be any thing unusual in the state of his face; but the moment he speaks or smiles, the mouth is drawn to the left side. When he laughs, the distortion is increased; and when he sneezes, the difference between the two sides is quite extraordinary.

"On holding ammonia to his nose, it was observed that he could not inhale freely with the right nostril; and, on examining the state of the muscles, when the act of sneezing was excited by the ammonia snuffed up by the left nostril, it was found, that not only those of the right side of the nose and mouth, but also of the eyelids, were passive, while all the muscles of the left side were in full action. When he blew, or attempted to whistle, the air escaped by the right angle of the mouth, the right buccinator not at all corresponding in action with the muscle of the left side, nor with that of the muscles of the chest and neck, by which the air was expelled. The sensibility of the paralyzed cheek was equal to that of the other side, and he could close his jaws with equal force on both sides."

The early history of the case, according to the account given by the patient's friends, was this:—

* This opinion I beg leave to let remain as in former editions, as implying my conviction of the importance of those nerves which I have since proved.

"He was seized with a severe pain under the ear, and in a short time became so delirious, and his face so distorted, that the people in whose house he lodged, supposing him to be mad from brain fever, carried him to the parish workhouse. There he lay until his friends discovered him, and brought him into the hospital. It was then found, that the phrenzy which had led the people of the lodging-house to suppose that he was mad, was only a high state of delirium, in consequence of a severe attack of cynanche parotidea; indeed, the inflammation had run so high, that an abscess formed and burst under the ear. When the swelling subsided the degree of paralysis was very observable.

"The delirium and the paralysis of the face naturally led the medical gentlemen, who first saw this patient, to suppose that the symptoms were caused by an affection of the brain. Luckily, the treatment generally followed in cases of phrenitis, was best adapted for the particular affection which had caused both the delirium and the paralysis. The portio dura being engaged in the inflammation under the ear, was the true cause of the paralysis."

For the next case I am indebted to a physician in Worcester:—

Worcester, July 25, 1824.—"Dear Sir:—My acquaintance with the nature of your late researches upon the functions of the nerves induces me to send you the following case:—

"A young gentleman, aged 14, residing in the village of Kempsey, in this county, was observed by his family to have the expression of his countenance much altered. As long as the features were quiet nothing unusual was observable in the countenance; but as soon as any passion was excited, the expression of the face was so different to what was natural to him, that his brothers and others of the family complained of his 'making faces at them.' He, in fact, only smiled, laughed, or frowned upon the left side of his face, the muscles of the right side remaining inactive; and, as they passively yielded to the contraction of the muscles of the left side, the countenance, of course, was much distorted whenever these were called into action. He lost the power of whistling, and, for the same reason, of blowing, and was unable to close his right eye. The sensibility of the right side was as perfect as that of the left. He was quite unconscious of any change in himself, and was not at all aware of the distortion of his countenance when he smiled, &c. This affection did not occur suddenly, but seemed gradually to increase, and became so evident in the course of a week, as to induce the father of the young man to send for his apothecary, Mr. Bick, of Kempsey. When Mr. B. saw him he found the symptoms as above stated; but upon examining the right side of the face more minutely, he discovered a fullness immediately beneath the right ear, produced by a hard, fixed, and indolent tumour, lying between the ramus of the lower jaw and the mastoid process of the temporal bone.

"He ordered him some aperient medicine, and directed the tumour to be rubbed with camphorated oil. In a fortnight the tumour disappeared, and with it, gradually, the paralysis of the muscles of that side of the face. It is a fortnight since Mr. Bick first saw him, and he has now recovered every power, excepting that of blowing or whistling. I saw him several times during the progress of his cure. It appears to me that the portio dura of the seventh pair was, in this case, injured by the pressure of an enlarged gland soon after its emergence from the stylo-mastoid foramen, and that upon the removal of the pressure its functions were restored.

"I remain, dear sir, your obedient servant,

"JONAS MALDEN, M. D."

The danger to which the eye is exposed by paralysis of the portio dura, or by any operation on the face, in which its functions are not attended to, is well illustrated by the following case:—

"This poor man, about nineteen years ago, was attacked by a severe pain accompanied with discharge from the right ear. After a paroxysm severer than usual, he found, on getting up one morning, that the right side of his face was paralytic. His present condition, and the description which he gives of the progress of the symptoms, prove that the same results followed this paralysis, as in the instances already related. But what this poor fellow particularly laments is, that since the day he was first attacked, he has not been able to close his right eye; and well he may regret this, for the constant exposure of the eye to the light and dust has been the cause of many attacks of inflammation, and, consequently, of opacity of the cornea, so that the vision is now entirely lost. This, I fear, will often occur in similar cases, for I have observed that the eye has always become inflamed in those animals in which the portio dura has been cut. It is worthy of remark, that the inflammation has been more severe in the dog and in the ass than in the monkey. One great source of the increase of the in-

flammation is the purulent secretion from the conjunctiva; this the monkey wiped away with his hand; but it lodged between the eyelids of the dog and of the ass, so as to form an additional source of irritation."

The ultimate effects of the loss of power over the muscles of the face, in consequence of an affection of the portio dura, are shown in the following extract:—

"A most remarkable appearance in the face of Garrity is the wasting of all those muscles of the face which are subservient to respiration and expression. His cheek is so thin that when he speaks it flaps about as if it were only skin, and the corrugator supercilii and occipito-frontalis, which are principally muscles of expression, are so wasted, that we might, at first sight, suppose they had been removed by operation, and that now the bones were only covered by skin. There can be little doubt that the wasting of these muscles has been in consequence of their long inactivity; since the masseter and temporalis muscles of the same side, which retain their office, are not at all diminished in size, being as large as those of the opposite side."

A curious example of a contrary effect produced on the growth of the muscles of respiration and expression, by an injury of the portio dura, was afforded in an experiment made upon a young dog. After the nerve was cut he was taught to snarl whenever a stick was held out to him; this being often repeated, the muscles of the side upon which the nerve was entire, became very strong, while those on the paralysed side rather diminished than increased as the dog grew older. In a few months the one side of the face was much larger than the other. Every day we see similar results following palsy of the muscles of the limbs.

Many instances will now occur to my reader of cases where the paralysis of the face, consequent on a local affection of the portio dura, has been mistaken for an attack of apoplexy, and the patient treated accordingly. In one case the patient, after having undergone the discipline of bleeding, purging, and starving, and after having had his head shaved and blistered, was suddenly cured by the bursting of an abscess in his ear.

In another case, the disease commenced with a violent pain below the ear, and in a short time one side of his face became paralysed. For this paralytic affection he consulted many eminent men. The first plan of treatment was bleeding, blistering, and starving, the disease being supposed to have its origin in the brain; but as he got rather worse than better under this treatment, he was put upon a course of mercury, which was carried to such an extent, that he lost several of his teeth. After he recovered from the bad effects of the mercury, he was recommended to attend only to the state of his digestive organs. But the blue pill had no effect upon the distortion. The last advice which this gentleman received was to wear an issue in his neck; with this, however, he has not complied, as he feared it would, like some of the other remedies, have the effect of rendering him more uncomfortable.

A great many cases, somewhat similar, have been presented to me by my pupils.

The first regards a patient who had suffered an attack of common apoplexy; it may be offered in example of that train of symptoms which is consequent on an affection of the original or symmetrical system of nerves, and as distinguishable from those which follow an affection of the superadded class. The second is of a man, in whom both the portio dura and the fifth had been injured by a blow; and the third is of a patient in whom both these nerves seem to have been affected by a disease within the skull.

J. Cooper.—This man's general appearance is completely that of an old paralytic, but the distortion of his face is more remarkable than usual, in consequence of the right or paralyzed side being marked with a red blotch.

The arm and leg of the same side are nearly powerless, his intellect is much impaired, and his memory gone. The history of his case was given very clearly by his wife; according to her account, her husband was, for the first time, attacked with apoplexy about seven years ago; from this attack he gradually recovered, but at the end of twelve months he was a second time seized, and, since that period, he has had two distinct attacks every year; for the last two or three years he has been nearly in the same condition as at present.

State of the cheeks and mouth.—When he is made to laugh, the right cheek rises in the same degree with the left; when he blows (he always bursts into a laugh when asked to whistle), the buccinator of the right cheek is in as much action as on the other side. When his nose is irritated by snuffing ammonia, the actions of the muscles, preparatory to sneezing, are equal on both sides of the face. These phenomena prove that the muscles of both cheeks are perfect in their actions as far as they are regulated by the respiratory nerve; they stand in contrast with the state of the same muscles in the cases related, when the act of sneezing was excited.

The next inquiry related to the influence of the branches of the fifth pair of nerves.

The right cheek, and the right side of the mouth, fall lower than the left. When a piece of bread was put between the teeth and right cheek, the patient could not push it from its place, but was obliged to pick it out with his tongue. The saliva constantly flows from the right side of his mouth, and when drinking, part of the fluid escapes from the same side. The loss of the sensibility of the orbicularis oris was farther shown by the inability to hold a pencil or a tobacco-pipe in the right side of his mouth.

The comparative degree of sensibility in the two cheeks was next examined; when he was pricked on the right cheek with a needle he seemed perfectly insensible, even though I drew blood, but on giving the least prick to the left side, he immediately started; the same difference in the degree of sensibility was observable in pulling a hair from each whisker (the sensibility of the right and left limb corresponded with that of the cheeks.)

On putting hartshorn to the right nostril he inhaled it as well as with the left, and immediately all the symptoms observable in a person about to sneeze were presented.* As the nose was turned up, and the alæ nasi of both sides were equally in action, this was a sufficient proof of the state of the paralyzed side being here very different from the condition described in the foregoing cases. The influence of the fifth pair within the nose was tried: by tickling the inside of the right nostril no effect was produced; but on tickling the left nostril the symptoms of sneezing were evident.

The motion of the eye was perfect.

He could close the eyelid of the paralyzed side as well as the other; and when his nose was irritated by the hartshorn, or when he laughed, the orbicularis oculi and corrugator supercilii were in complete action, so that there was not here that heaviness in the expression of the upper part of the face, which is so remarkable in paralytic persons. Here, then, was proof that those actions of the eyebrows, which we find to be deficient when the portio dura is affected, are, in a case of common palsy, left entire; indeed, we may have daily opportunities, while walking in the streets, of observing that patients with palsy of one side of the body, have no difficulty in closing the eyelids.

In the next Case, both systems of nerves seem to have been affected.

Phipps, a bricklayer, on the 1st of September, 1821, fell from a scaffold thirty feet high. His right clavicle was broken, his right loin and hip were much bruised, and he received a severe contusion on the head, the marks of which were particularly observable in a puffiness behind the right ear, and in bleeding from the same ear and from the nose.

He was in a state of stupor when brought into the hospital, but from this he recovered in the course of the day. For the two or three first days he appeared to suffer only from the effects of *concussion*, never having any of those symptoms which are generally attributed to *compression*. On the fourth day it was observed, that the angle of the mouth was drawn rather to one side, and there was also a degree of inequality in the contraction of the pupils.

On the sixth day it was remarked, that while he was asleep, the right eye was more than half open, while the left was closed.

The notes of the case are very full up to the 24th of September, and show that the patient had, during the interval, gone through the common series of symptoms which accompany that slight inflammation of the brain which is often the consequence of concussion.

On the 1st of October, he was made an out-patient, his face being, at this time, very much distorted.

The general appearance of his face at this time was that of a man who has suffered paralysis from apoplexy. But it was further remarkable, that when he spoke or laughed, the distortion was much increased, the mouth being pulled more to the left side than I ever saw in any other patient.

The following are the notes that were taken at this time. There appears to be total paralysis of the muscles of the right side of the face. When he smiles or laughs they are passive, while those of the left are regularly in action. If he attempts to whistle, he cannot close his lips sufficiently; when he blows, the right cheek is dilated, but passive, like a distended bladder; he can smoke by putting the pipe into the left side of his mouth; he throws the smoke out of the right side, but in doing this, the action is evidently confined to the muscles of the left cheek.

The cheek and mouth hang down, as in the common case of hemiplegia—he cannot

* The apparent sensibility of the nostril over which the fifth had lost its influence may be explained, by supposing that the fumes of the ammonia passed by the posterior nares to the other nostril, and thus caused sneezing.

by a voluntary act move his cheeks; when a piece of bread is put between the cheek and teeth of the right side, he cannot push it out with the buccinator, but picks it out with his tongue. He cannot hold his pipe or my pencil with the right side of his lips. These may be considered as sufficient proofs of the total paralysis of the muscles of the face.

The difference of the sensibility in the two cheeks was very distinct. When a hair of the right whisker was pulled, he was not conscious of pain; but he started immediately on pulling one from the left. When his cheeks were pricked with a needle, his expression was—"I feel you push against the right side, but in the left you prick me." When he brought his jaws forcibly together, he said he was not conscious of striking his teeth on the right side, though he felt them most distinctly on the left. On examining the state of the nose, we found that it was impossible to excite the muscles of the right nostril to any action.

The state of the right eyelids and eyebrow corresponded with those of patients who have paralysis of the portio dura, for both the orbicularis oculi and corrugator supercilii were so completely paralytic, that he could neither close his eye, nor knit his brow on the right side.

On examining how far the branch of the fifth, which passes to the eye and eyelids, was affected, we found that the symptoms did not exactly correspond with those observed in the parts regulated by the other divisions of the fifth pair, and particularly in the degree of sensibility; for when a hair was pulled from each temple, or from the eyebrows, the pain felt in the two sides was nearly the same; neither the temporalis, nor masseter muscles of this side were paralyzed. The motions of the eye-ball were so far perfect, that he could follow an object carried before him, but he could not direct both eyes truly, he saw double. The contraction and dilatation of the pupil of the right eye, were much the same as in the other eye.

He can put out the tongue, and move it in every direction with the greatest ease: the motions are all apparently correct and natural; he can throw a morsel from one side of the mouth to the other, and towards the throat, and he can pick it out from between his cheek and teeth.

These observations led us to conclude, that not only the motor linguæ, or ninth nerve, but also the glosso-pharyngæal were perfect.

This case differs from the common examples of partial paralysis of the face, not only in there being evident marks of paralysis while the muscles of the face are at rest, but in the sensibility of the skin of the same side being in a great measure destroyed. It differs also from the case of hemiplegia.

The first difference which we observe in it, from the case of common hemiplegia, is, that the paralysis is confined to the face. Secondly, that the paralysis is on the same side with that on which the head is injured. Thirdly, that the palsy is more evident when the patient is made to sneeze or laugh. From these circumstances, we may conclude that there was here an injury of the skull affecting both the fifth and the seventh nerve, i. e. in their course, not in the brain.

"*James Gulland*, ætat. 26.—Was admitted into the Middlesex hospital, April 15, 1823. His mouth and left cheek are twisted towards the right side: the whole surface of the left side of his face is insensible: he has not the power of moving the eye of that side, and it was lately become inflamed; he complains of a deep pain in the temple of the same side.

"His trade has been so profitable as to enable him to live in a most dissipated manner during the last five years. He has frequently strolled about the streets at night in a state of drunkenness, and has for three weeks never thrown off his clothes, and has been seldom in bed. He has been twice affected with syphilis: he was confined by his first attack for eighteen months, during which time he was under the influence of mercury. After regaining his health, he frequently experienced a pricking pain in his left eye and temple, so severe as to prevent his reading, especially by candle-light. About twelve months ago he was knocked down: he fell on the back of his head, and wounded the occipital artery; he thinks that he has never been quite well since that time. On the 13th of October, last year, one of his comrades noticed to him that his mouth was drawn to one side; this induced him for the first time to observe in a looking-glass the condition of his face. He tried to spit, and observed that his saliva, instead of passing through the centre, was squirted out of the right corner of his mouth, which was contracted. His lips were in other respects perfectly natural, being possessed of sensibility and the power of motion. He could then likewise close the eyelids of the left eye, but to do this he required to shut the other eye also.

"On the following morning he was conscious of a peculiar numbness above the left

eye. This numbness imperceptibly and gradually spread over the left cheek, and at the same time affected the external and internal surfaces of almost all that side of the head. He lost the sense of taste on the left side of his tongue, and in little more than a fortnight he became deaf in the left ear. Now he complains principally of the inflamed condition of the left eye, (which commenced about ten days ago,) and of the pain in his left temple.

"The above circumstances he himself could relate distinctly; the following is an account of his present condition, April 20.

"The left side of his face is drawn towards the right, and is slightly œdematous. The left nostril is collapsed, and does not expand during breathing. The mouth is distorted towards the right side. When he speaks, the two sides of his face are distinctly marked by a line of division; the action of the muscles of the mouth and nostrils, on the right side, being quite distinct, while those of the left are motionless. He has lost all power over the left eye-lids; until lately, he could elevate his upper eye-lid, although, since the time of his first attack, he has always experienced a certain difficulty in closing it. At present the eye-lid hangs down flaccid and shut; he is unable to press the eye-lids together.

"The sensibility to touch is gone on the greater part of the left side of his head and face, and this insensibility extends to the vertex of the head. The surfaces of the conjunctiva and eye-lids are also completely insensible, yet the eye is inflamed and ulcerated; the left side of the nose, the cheek, the upper and lower lips, are all equally insensible; but he is sensible when touched upon the left side, below the under jaw, and even over the lower jaw itself, as high as the inferior part of the lower lip. The external ear, and likewise the back part of his head, nearly as high up as the vertex, retain their natural sensibility.

"The internal surfaces of the left nostril, and of the mouth and gums on the same side, are insensible to touch; and he has neither the sense of taste or common feeling in this side of the tongue; in consequence of this, portions of food have sometimes lodged within the left side of his mouth, without his being aware of their presence, until they became actually putrid.

"The power of moving his tongue is quite perfect: if at rest, it lies in its natural position within the mouth; nor is it dragged towards either side when he is told to move it. Being tickled with a probe on the left side of the root of his tongue, the sensation of nausea and the effort of retching are produced as on the opposite side. He can open and close his jaws; yet it can be observed, when he is made to clench his teeth, or to bite forcibly, that the masseter and temporal muscles of the right side are hard, rigid, and strongly in action, while the same muscles belonging to the opposite side are totally different in that respect, for they feel soft and flaccid.

"With regard to his left eye, it has been already noted that it is deprived of common sensibility, and that he has no power of shutting or raising his eye-lid. Besides these, he possesses no command over the eye-ball: his eye remains fixed and motionless, and directed straight forwards when he attempts to turn it towards objects. No motion exists in the pupil when a light is presented to the eye. He has the power of vision, although he sees dimly; this is, probably, on account of the eye being inflamed and the cornea ulcerated and opaque. When both his eyes are closed, he is sensible of a red light in the left eye, while nothing is visible in the right one.

"He was questioned as to the period when he observed that he had lost the power of directing the left eye to objects, but he was unable to inform us, because he imagined always that that eye was as much in motion as the other.

"August, 1821.—This man is still alive, several of the symptoms of paralysis both of the portio dura and of the fifth are become more indistinct; he has regained a little power over the motions of the eye-lids, and of some of the muscles of the face, and the surfaces are endowed with a slight degree of sensibility."

In this case we may observe, that the symptoms show the affection to be limited to the seventh and fifth nerves of the left side, and they best correspond with the supposition, that a disease of the bone, or membranes, has affected these nerves in their course, and is gradually extending forward to the nerves of the orbit.

I shall close the narration of these cases by the statement of a circumstance which occurred to me a few years ago:—

A gentleman, in the vigour of life, came into my room to consult me, having the most remarkable distortion of countenance I had ever seen. He proceeded to state to me what he conceived to be the cause of this paralytic affection of one side of his face: he had been knocked down by a blow upon the ear, and had remained a whole night insensible, with bleeding from the ear, from which time his features had been thus drawn

to the opposite side. I thought I should give him comfort by stating to him that this was a paralysis attributable to the injury of the bone, and that, as it had not proceeded from an apoplectic tendency, there was no danger of a future attack or of increase of the paralysis. But this was not what he expected from me; he had consulted my brother, then at Rome, and he had proposed to cure him by an operation.

I was quite at a loss to conceive what operation his ingenuity had contrived to relieve so remarkable a deformity. This gentleman mentioned that it had been intended to make three small incisions on different parts of his face, so as to restore the balance of his features: and he was obviously disappointed in finding me less intelligent, or less able than he had expected, and we parted.

On reflecting on the conversation of this gentleman, it occurred to me that my brother, believing that the paralysis had arisen from an injury of the fifth nerve, had proposed to restore the features to an equilibrium by dividing the branches of the same nerve on the opposite side; trusting, no doubt, to the features being still animated by the seventh pair of nerves. A singular consequence would have resulted from such an operation. The features would have remained drawn to the same side as before, and he would have been deprived of all sensibility of that side! If it was designed to have cut the *portio dura* of the side contracted, a more unhappy consequence would have resulted; for he could never afterwards have spoken, or even have kept his lips to his teeth, or retained the saliva. The features of both sides would have fallen in relaxation, and the eye would have remained uncovered, and he would have lost his sight by the inflammation and opacity consequent on its continual exposure!

It must, indeed, appear a singular circumstance now, that so many surgeons were cutting the branches of the fifth pair of nerves for the tic doloureux, without being led to inquire more particularly into the functions of the several nerves of the face. We see how near my brother's ingenuity was leading him wrong, from having often cut the fifth pair without producing horrible distortion. And I believe that the very same mistake led an honourable baronet to say that I had not cut the frontal branch of the fifth pair of nerves on the face of a nobleman, when I had only cut that branch without interfering with the branches of the *portio dura*, and consequently without producing the slightest effect on the muscles of the eyebrow. All these circumstances, I hope, tend to enforce the importance of anatomy.

At this stage of the description of the nervous system we experience some difficulty; for if we follow, undeviatingly, the manner of Willis, we shall certainly fall into the same mistakes. Instead of following the nerves of the brain and spinal marrow according to their regular succession, it will be necessary to class them according to their functions. This will oblige us to throw together some of the nerves of the brain, and some of the spinal marrow.]

OF THE RESPIRATORY NERVES; MORE PARTICULARLY, VIZ. THE GLOSSO-PHARYNGEAL NERVE, PAR VAGUM, SPINAL ACCESSORY, DIAPHRAGMATIC NERVE, AND EXTERNAL RESPIRATORY NERVE.

ORIGINS OF THE RESPIRATORY NERVES.

The nerves on which the associated actions of respiration depend, and which have been proved to belong to this system by direct experiment and the induction from anatomy, arise very nearly together. Their origins are not in a bundle or fasciculus, but in a line or series, and from a distinct column of the spinal marrow. Behind the *corpus olivare*, and anterior to that process which descends from the cerebellum, the *corpus restiforme*, a convex strip of medullary matter, may be observed; and this convexity, or fasciculus, or *virga*, may be traced down the spinal marrow, betwixt the sulci, which give rise to the anterior and posterior roots of the spinal nerves.

This portion of medullary matter is narrow above where the *pons Varolii* overhangs it. It expands as it descends; opposite to the lower part of the *corpus olivare* it has reached its utmost convexity, after which it contracts a little, and is continued down the lateral part of the spinal marrow.

From this track of medullary matter, on the side of the *medulla oblongata*, arise in succession, from above downwards, the *fourth* nerve; the *portio dura* of the seventh nerve; the *glosso-pharyngeal* nerve; the nerve of the *par vagum;* the *nervus ad par vagum accessorius;* the *phrenic*, and the *external* respiratory nerves.

It is probable that the branches of the intercostal and lumbar nerves, which influence the intercostal muscles and the muscles of the abdomen in the act of respiration, are derived from the continuation of the same cord or slip of medullary matter. Nor will it escape observation, that the nerves called phrenic and external respiratory, though coming out with the cervical nerves, do, in all probability, take their origin from the same portion of the medulla spinalis with the accessory nerve.

The intercostal nerves, by their relations with the medulla oblongata, are equal to the performance of respiration, as it regards the office of the lungs; but they are not adequate to those additional functions which are, in a manner, imposed upon the respiratory apparatus, when they are brought to combine in other offices.

OF THE MUSCLES OF THE TRUNK WHICH ARE BROUGHT IN AID OF THE COMMON RESPIRATORY MUSCLES.

If we look upon the frame of the body, for the purpose of determining which are the muscles best calculated to assist in the motions of the chest when there is an increased or excited action, we shall have little difficulty in distinguishing them, and we shall have as little hesitation in assigning a use to the nerves which supply these muscles exclusively. For these nerves have the same origin: they take an intricate course, threading and passing betwixt other nerves and other muscles, to be entirely given to the muscles which heave the chest.

In this enquiry it is necessary to observe, that the life of animals is protected by a particular sense, which gives rise to an instinctive motion of drawing the breath, and by which the chest is suddenly and powerfully expanded on exertion or alarm. The start, on sudden alarm, is accompanied with a rapid expansion and rising of the chest; and the voice, at such a moment, is produced by suddenly inhaling, and not by expiration; and this expansion of the chest combines with the preparation for flight or defence, since the extension of the muscles lying on the breast and back is produced by this motion, and since they are thereby rendered more powerful in their influence upon the arms or anterior extremities. It cannot escape observation, that oppression and difficulty of breathing is exhibited in gasping and forcible inspiration, in drawing the breath, not in throwing it out.

Accordingly, when we examine the trunk of the human body, we have no difficulty in distinguishing the muscles most capable of raising the chest; and these, in effect, we see powerfully influenced in deep inspiration, whether the action be voluntary, as in speech, or involuntary,

as in the last efforts of life, when sense is lost. They are the mastoid muscle, the trapezius, the serratus magnus, and the diaphragm.

1. STERNO-CLEIDO-MASTOIDEUS.—This muscle, by its attachment to the sternum or breast-bone, raises or heaves the chest; and the operation of this muscle is very evident in all excited states of respiration, in speaking, and still more in singing, coughing, and sneezing. But there is something necessary to the full effect of this muscle on the chest; for otherwise it will be a muscle of the head, and not of the chest.

2. The TRAPEZIUS must fix the head or pull it backwards before the *mastoideus* can act as a respiratory muscle, and how they are combined we shall presently see. The position of the head of the asthmatic during the fit, as well as the posture of the wounded or the dying, prove the influence of the upper part of the trapezius in excited respiration.

The trapezius has a still more powerful and important influence in respiration when the action rises above the ordinary condition; and that is, by drawing back the scapula, to give the necessary effect to the action of the serratus magnus.

3. The SERRATUS MAGNUS ANTICUS being extended over the whole side of the chest, and attached in all the extent from the second to the ninth rib, is very powerful in raising the ribs; but it cannot exert this power independently of the trapezius, since, without this combination, its force would be exerted in moving the scapula, and not the ribs; unless the scapula be fixed, or pulled back by the *trapezius*, the *serratus* is not a muscle of respiration.

In this manner do these three powerful muscles hang together in their action, combining with the diaphragm to enlarge the cavity of the chest in all its diameters.

The course of our inquiry leads us to ask, Are these muscles privileged above others by any peculiarity of nerves? And the answer is plain: To these muscles alone, are the nerves, which I am about to call respiratory nerves of the chest, distributed.

ANATOMY OF THE RESPIRATORY NERVES OF THE PAR VAGUM.

The PAR VAGUM, or, as we are to describe it, *nervus vagus*, is one of three nerves which Willis describes as the eighth pair of nerves, viz. nervus vagus, glosso-pharyngeus, and spinal accessory. These go out through the foramen lacerum, formed betwixt the occipital and temporal bone.

THE GLOSSO-PHARYNGEAL NERVE

Is the first to be described. This nerve, parting from its connection with the par vagum and accessory nerve, perforates the dura mater separately from them, and, in many subjects, passes through an osseous canal altogether distinct. When it escapes from the cranium, it lies deep under the angle of the jaw, and passes across the internal carotid artery upon its outer side. It is to be seen by lifting the styloid muscles, at which point it sends small branches to the styloid and digastric muscles, and to join the par vagum. It sends also some very small twigs down upon

the internal carotid artery, some of which join that pharyngeal branch* which is formed from the par vagum and accessory nerve.

Several branches communicate with the ganglion and plexus (expansio plexuosa) of the pharyngeal nerve, and are distributed in the superior constrictor and the stylo-pharyngeal muscles.

The trunk of the glosso-pharyngeal nerve, after giving off the nerves which pass in the direction of the internal carotid artery, continues its course attached to the stylo-glossal and stylo-pharyngeal muscles, to which it gives more branches, and also to the upper division of the constrictor pharyngis. A division of the extreme branches of this nerve terminates in the tongue, under the denomination of RAMI LINGUALES PROFUNDI, RAMI LINGUALES LATERALES, NERVI GLOSSO-PHARYNGEI.† Amongst the branches of the pharyngeal nerve is to be enumerated that which turns back to join the ninth pair in its distribution to the tongue.‡ The remaining branches of the glosso-pharyngeal nerve are distributed in innumerable filaments upon the pharynx; they are joined by branches from the ganglion of the sympathetic nerve. A remarkable branch of this nerve goes to the papillæ, on the surface of the posterior part of the tongue; and it is probably on the excitement of this, that the pharynx and tongue are brought into activity in swallowing.

I consider the glosso-pharyngeal to be the nerve of deglutition. I have elsewhere explained, that the act of deglutition is necessarily joined with that of respiration.

PAR VAGUM.

The nervus vagus is the grand division: the middle fasciculus of the three nerves composing the eighth pair. It arises in filaments from that column of the lateral part of the spinal marrow which reaches up behind the corpus olivare. In its exit from the cranium, it is divided from the jugular vein by a small partition of bone. These filaments, indeed, sometimes pass out separately, and join to form the trunk of the nerve when out of the skull. Deep under the lower jaw, and the mastoid process of the temporal bone, the glosso-pharyngeal nerve, the par vagum, the spinal accessory, the sympathetic nerve, the portio dura of the seventh, and the upper cervical nerves, are entangled in a way which will fatigue the dissector. The par vagum, lying behind the internal carotid artery, and as it were escaping from the confusion of the ninth, accessory and glosso-pharyngeal nerves, descends and swells out into a kind of ganglion.§ We now observe three branches to be sent off: The

* This is a branch to the pharynx, which is formed by the par vagum and the spinal accessory of Willis. After this nerve is formed, it again forms connection with the par vagum.—Pain in the throat having been observed by Galen to extend to the back, Scarpa explains it on the ground of this connection with the spinal accessory nerve.

† Scarpa. There is then a plexus formed, which is called the Circulus Tonsillaris Anderschii. It lies on the side and nearly on the dorsum of the tongue, and sends out some very delicate twigs to the tonsils.

‡ Sabbatier.

§ *Truncus gangliformis* OCTAVI, *tumidulum*, *corpus olivare* Fallopii; but it is suspected that in this he meant the ganglion of the sympathetic nerve.

Prochaska notices this slight swelling formed upon the par vagum, where it is emerging from the skull; it is just beside the superior cervical ganglion of the sym-

FIRST and SECOND PHARYNGEAL NERVES, which pass to the constrictores pharyngis muscles, and the SUPERIOR LARYNGEAL NERVE. This last-mentioned nerve is even larger than the glosso-pharyngeal nerve. It is behind the carotid artery, and passes obliquely downward and forward. In its progress the principal branch passes under the hyo-thyroideus muscle, and betwixt the os hyoides and the thyroid cartilage; while others, more superficial, pass down, and are connected with the EXTERNAL LARYNGEAL, or PHARYNGO-LARYNGEUS; which is a nerve formed by the sympathetic and par vagum conjointly. The principal branch of the internal laryngeal nerve runs under the hyo-thyroideus, and is distributed to the small muscles moving the cartilages. The minute extremities of this nerve pass also to the apex of the epiglottis, and the glandular membrane covering the glottis. We have, at the same time, to remark, a very particular communicating nerve betwixt this internal laryngeal nerve and the recurrent branch of the par vagum. This branch is described by Galen. The par vagum continues its uninterrupted course betwixt the carotid artery and jugular vein; it is involved in the same sheath with these vessels, but lies rather behind them. In this course down the neck, it sometimes sends back a twig which unites with the ninth pair, and when near the lower part of the neck, it sends forward twigs to unite with those from the sympathetic nerve, which pass down to the great vessels of the heart, to form the superior cardiac plexus. On the right side, those nerves to the great vessels are in general given off by the recurrent nerve.

The nervus vagus now penetrates into the thorax by passing before the subclavian artery; it then splits into two. The main nerve passes on by the side of the trachea, and behind the root of the lungs; while the branch, on the right side, turns round under the arteria innominata, and on the left, under the arch of the aorta, and ascends behind the trachea to the larynx.

This ascending branch of the par vagum is the RECURRENT NERVE. On the right side it is sometimes double. It ascends behind the carotid artery, and sometimes is thrown round the root of the thyroid artery. On the left side, this nerve, from its turning round the arch of the aorta, is much lower than on the right, it gives off filaments which go to the lower cardiac plexus, after having united with the branches of the sympathetic. Under the subclavian of the right side, also, there are sent branches from the recurrent to the cardiac plexus; and on both sides there pass branches of communication betwixt the sympathetic nerve and the recurrent. When the recurrent nerve has turned round the artery, it ascends in a direction to get behind the trachea, and here it lies betwixt the trachea and œsophagus. It now sends off many branches to the back and membranous part of the trachea which pierce this posterior part, to supply the internal membrane. It gives also branches to the œsophagus and thyroid gland. The final distribution of this nerve is to the larynx. It pierces betwixt the thyroid and cricoid cartilages, and separates into many filaments, which terminate in the crico-aryte-

pathetic nerve, that is about where it is giving off the superior laryngeal nerve. There is also a representation of it in one of his plates; but it is in every respect unlike a true ganglion, although he says there is to be found some of that reddish substance in it which is found in other ganglions. Prochaska, Tab. ii. de Struct. Nerv.

noideus, lateralis, and posticus, and thyreo-arytenoideus, and in the membrane of the larynx. We have already mentioned the branch of communication betwixt the recurrent and internal laryngeal nerves, and Sabbatier describes a branch of the recurrent, which sometimes ascends and joins the sympathetic high in the neck.

Two cases, mentioned by Galen, of scrophulous tumours in the neck opened, where the consequence was loss of voice, have tempted many anatomists to institute experiments on the recurrent and internal laryngeal nerves.* Notwithstanding the deep situation of those recurrent nerves, Galen says, they were cut in these cases, and he believed that the branch of communication betwixt the laryngeal and recurrent restored the voice after some time had elapsed. Both the internal laryngeal and recurrent nerves are necessary to the formation of the voice. Experiments have been made upon them in dogs, and the result is curious; although the lesser changes of the strength, acuteness, and modulation of the voice could not be well observed in the lower animals. When the laryngeal nerve is cut, the voice is feeble, but acute; when the recurrent nerve is cut, there is a relaxation of those muscles moving the arytenoid cartilages which command the opening of the glottis, and in consequence the voice is flatter or graver, or more raucous.

The par vagum, after sending off the recurrent nerve, descends by the side of the trachea. Before it passes behind the vessels and branch of the trachea going to the lungs, it sends minute branches which form the ANTERIOR PULMONIC PLEXUS. This plexus is entangled in the connections of the pericardium, and is dissected with difficulty. The branches of this plexus throw themselves round the pulmonic arteries and veins, and follow them into the lungs.

The par vagum, passing on behind the root of the lungs, forms the POSTERIOR PULMONIC PLEXUS. From this also the nerves proceed into the lungs, by attaching themselves to the pulmonic arteries and veins, and bronchial arteries, and the branches of the trachea.†

The trunks of the nerve, continuing their course upon each side of the œsophagus, unite and split into branches, and again unite so as to

* Martin, in the Edinburgh Essays, Professor Sue of Paris, Dr. Haighton, in the Memoirs of the Medical Society of London, Cruikshanks, Professor Scarpa, Arnemann, Majendie, &c.

† *Nerves of the Lungs.*—Galen, Vesalius, and others, conceived that there were very few nerves sent to the lungs, and that those which were, went only to the membranes, and not to the substance of the lungs. They believed also that the discharge of blood from the lungs and the existence of vomicæ without pain, while there was great pain in peri-pneumony, was a confirmation of this opinion. Fallopius corrected this idea, and shewed that the bronchiæ were also attended through their course with nerves. There often exist vomicæ and effusions of blood in the lungs; and Haller says, the lungs can be lanced without the animal feeling pain, but still the bronchiæ are extremely sensible.—Water accumulated in the interlobular cellular membrane, or the infraction of blood into it, gives no acute pain, but only a sense of weight and difficulty of breathing. It is an oppression in a great measure depending upon the return of the blood from the lungs, unchanged in consequence of the compression of the cells. In these observations they have not sufficiently distinguished betwixt common sensibility and the appropriate sensibility of the organ. Are not the stomach and intestines sensible? and yet they are not to handling.

The connection betwixt the stomach and bronchiæ, through the medium of the par vagum and pulmonic plexus, is evident from those asthmatic attacks which depend upon foulness in the stomach.

form a netting upon the œsophagus; these are the ANTERIOR and POSTERIOR PLEXUS GULÆ, or ŒSOPHAGEAL PLEXUS. The par vagum, thus attached to the œsophagus, pierces the diaphragm with it, the anterior plexus unites again into a considerable trunk, and is attached to the lesser arch of the stomach. It stretches even to the pylorus, and sends its branches to the upper side of the stomach, and to the lesser omentum; at the same time it unites with the left hepatic plexus, some of its branches terminate in the solar plexus, which surrounds the root of the cœliac artery. The posterior œsophageal plexus, likewise uniting again into a considerable cord when it has come into the abdomen, sends branches to encircle the cardiac orifice of the stomach; it branches also to the inferior side and great arch of the stomach; it sends also branches to the splenic plexus and solar plexus.

Thus we see that the par vagum has a most appropriate name, and that it is nearly as extensive in its connections as the sympathetic itself. It is distributed "to the œsophagus, pharynx, and larynx; to the thyroid gland, vessels of the neck and heart, to the lungs, liver, and spleen, stomach, and duodenum, and sometimes to the diaphragm." The recollection of this distribution will explain to us many sympathies; for example, the irritability of the larynx in exciting coughing; the hysterical affection of the throat when the stomach is distended with flatus; the exciting of vomiting by tickling the throat; the effect which vomiting has in diminishing the sense of suffocation; the relations betwixt the heart and lungs; the lungs and stomach, and the stomach and heart.

The nerves which give rise to the extraordinary intricacy of this system on the side of the neck, are the spinal accessory nerve, the phrenic nerve, and the external thoracic nerve. The PHRENIC NERVE has its great root or origin from the fourth cervical nerve; and there joins this root, a more slender branch from the third cervical nerve. But, besides these roots, it has connections, which of themselves would mark the relations of the nerve; high in the neck it is connected with the *nervus vagus* and with the *lingualis medius*, while, at the same time, a branch is given off to the muscles of the larynx. The trunk of the nerve descends into the cavity of the thorax, and gives no branches, until arriving at the diaphragm, it sends out numerous diverging branches, which are lost in the substance of that muscle.

It has been long known that irritation of this nerve convulses the diaphragm, and that cutting it across paralyses that muscle. These facts, with the consideration of its course, prove it to be a respiratory nerve, and such has been the universal opinion.

But to what purpose should a distinct nerve be sent to the diaphragm, if the other muscles, seated externally, and which are associated in action with the diaphragm, and as important to respiration, were left without a similar tie to unite them with each other, and with the organs of the voice?

The *inferior external respiratory nerve* of the thorax (fig. 13. Pl. II.) is a counterpart of the internal or phrenic nerve. It comes out from the fourth and fifth cervical nerves, and often it is connected with the phrenic. It diverges somewhat from that nerve, because, instead of descending within the chest, it falls over the ribs, and descends in a distinct flat

trunk upon the outside of the chest, to be distributed entirely to the *serratus magnus anticus.* This muscle has other nerves coming from the spinal marrow, because it has to combine the motions of the frame in loco-motion. But the long descending nerve is a respiratory nerve; which we may know from its origin, course, and destination; in its origin and course it is like the diaphragmatic nerve, and in its destination also, since it is given to a muscle necessary to full inspiration.

I come now to the *spinal accessory nerve*, (fig. 11. Plate II.)* It is called here the superior respiratory nerve of the trunk. Experiments may take a colour from the preconceived idea, but the accurate investigation of the structure will not deceive us. The author, therefore, entreats attention to the anatomy of this nerve, as leading in the most conclusive manner to a knowledge of its functions.

It arises from the cervical portion of the spinal marrow; but instead of collecting its branches to go out by the side of the vertebræ, like the internal and external respiratory nerves, it shoots upwards through the theca of the spinal marrow, enters the skull, and joins the eighth pair of nerves; from which it has its term of accessory. We see the roots of this nerve as far down as the fourth cervical nerve.† These roots arise neither from the posterior nor the anterior column of the spinal marrow, but betwixt the posterior roots of the cervical nerves and the ligamentum denticulatum, and from the *column of medullary matter* above described. The origins of this nerve come off in one line, and that line is in the direction of the roots of the eighth pair, and of that nerve which has been proved to be the respiratory nerve of the face, the portio dura. In its ascent the accessory nerve is attached to the posterior root of the first cervical nerve.

The nerve having ascended through the *foramen magnum*, passes out from the skull associated with the nerves constituting the *eighth pair*, and in the same sheath with them; they all go out through the *foramen lacerum*, and by the side of the jugular vein. In this course the accessory nerve divides into two. One of these divisions joins filaments of the *par vagum;* and these again send nerves to the *glosso-pharyngeal* nerve; and sometimes a branch may be seen going to the *lingualis medius.* The more exterior division of the accessory nerve descends behind the jugular vein, and comes forward and perforates the mastoid muscle. In its passage through the muscle it sends off branches which course through its substance; and if, as sometimes happens, though rarely, the nerve does not pass through the muscle, these branches are, notwithstanding, invariably given to it.

When the nerve has escaped from the back part of the mastoid muscle, it forms a communication with that branch of the third cervical nerve that ascends behind the muscle; and nearly at the same time it is joined by a branch from the second cervical nerve. The superior respiratory nerve now descends upon the neck, and begins to disperse its branches in regular order to the edge of the trapezius muscle; four or five branches take their course to that muscle, separate into minute subdivisions, and are lost in its substance. One more considerable division,

* *Nervus ad par vagum accessorius.*
‡ In the ass its roots are seen to extend much lower down.

being the lowest of these, is joined by a long descending branch of the second cervical nerve. Increased by this addition, it descends under the trapezius and behind the clavicle. Following this descending branch, it will be found exclusively attached to the trapezius. Behind the scapula it is again joined by branches from the spinal nerves; and here a sort of imperfect plexus is formed, from which divisions of the nerve, still descending, follow the lower edge of the muscle, and are finally dispersed among its fibres.

This nerve arises from the same column with the respiratory nerves; it takes a most intricate and circuitous passage to form a junction with nerves which we know to belong to that class; it sends branches to join the nerves of the tongue and pharynx; it sends branches to the larynx in company with the branches of the *par vagum;* it then crosses the great nerves of the neck, passes under the spinal nerves, goes to no other muscles in its course, but lavishes all its branches on the mastoid and trapezius muscles. To an anatomist it is as plainly set forth as if it were written in our mother tongue, this is *the superior respiratory nerve of the trunk.**

COMPARATIVE VIEW OF THESE NERVES.

If we examine the *par vagum*, the *portio dura* of the face, the *external thoracic*, the *diaphragmatic*, and the *spinal accessory* nerves, by comparative anatomy, we shall conclude that they are all respiratory nerves, by their accommodating themselves to the form and play of the organs of respiration. In fishes the respiratory nerve† goes out from the back part of the *medulla oblongata.* When it escapes from the skull it becomes remarkably enlarged, and then disperses its branches to the branchiæ and the stomach. But from the same nerve go off branches to the muscles moving the gills and operculum, whilst a division of the nerve is prolonged under the lateral line of the body to the tail. It is said, this division sends off no branches, but this is not correct; it gives branches in regular succession to the muscles from the shoulder to the tail. Experiments have been made upon these nerves, but their detail would lead us too far. It is scarcely necessary to add, that there are neither phrenic nor spinal accessory, nor external thoracic nerves in fishes, the order of their muscular system not requiring them. In birds, the structure of the wing, and the absence of the mastoid muscle, render the spinal accessory nerve unnecessary; it is wanting, for the same reason that in the absence of the diaphragm there is no phrenic nerve. Quadrupeds have the three respiratory nerves of the trunk; but even in them there are variations in the muscular frame, which illustrate the appropriation of the nerves. The construction of the neck of the camel is like that of birds; there is a succession of short muscles along the side of the neck, and attached to the vertebræ; but there is no long

* *Lobstein*, in a dissertation on this nerve, finding the difficulty of accounting for the *nervous fluid* coming by a double passage to the muscle, concludes, *veniet forsan tempus quo ista quæ nunc latent, dies extrahat et longioris ævi diligentia.*

† The nerve which by its subdivision supplies the heart, lungs, and stomach, and the muscles of the gills.

muscle, like the *sterno-cleido-mastoideus*, contributing to the motion of respiration. There is, accordingly, no spinal accessory nerve in the neck of this animal.

We have a remarkable example of the manner in which these nerves vary in their course of distribution, and yet retain their appropriate functions, in the nerves of the neck of birds. In them, the bill precludes the necessity of the portio dura going forward to the nostrils and lips; the nerve turns backwards, and is given to the neck and throat; and it is particularly worthy of remark, that the action of raising the feathers of the neck, as when the game-cock is facing his opponent, is taken away by the division of this nerve. If we compare the anatomy of the facial respiratory nerve, in the various classes of birds, we shall find its distribution to be analogous to that of the same nerve in the different tribes of quadrupeds.

In the game-cock, a few branches of the nerves pass to the loose skin under the jaw, which is dilated in crowing, the greater number being distributed on the muscles of the neck, which causes the elevation of the feathers when he puts himself in an attitude for fighting. But in the duck, which, when enraged, has little or no power of expression, the same nerve is not larger than a cambric thread, and passes only to the skin under the jaw.*

THE FUNCTIONS OF THESE NERVES FARTHER ILLUSTRATED.

Before having recourse to experiments on brutes, we may observe what takes place in our own bodies. By placing the hand upon the neck, we may be sensible that the mastoid muscle has two motions. The lower extremity of the muscle is fixed when we move the head; but when we use the muscle in inspiration, the head, and consequently the upper extremity of the muscle, are fixed. Now, if we endeavour to raise the sternum through the operation of this muscle, we shall find that other muscles are, insensibly to us, brought into action, which have nothing to do with this raising of the sternum. For example, if we strain to raise the lower extremity of the muscle, we shall unavoidably produce an action of the muscles of the nostrils; by which association of actions, we shall discover that we are using the *mastoideus* as a respiratory muscle. If we reverse the action, and move the upper extremity of the muscle, other muscles will be drawn into co-operation, but they will be such as assist in the motion given to the head. Or we may vary the operation in another way. In snuffing or smelling, if we place the fingers on the portions of the mastoid muscles which are attached to the sternum, we shall find every little motion of the nostrils

* These respiratory nerves of the thorax, the diaphragmatic, the superior, and the external thoracic nerve, are all nerves of *inspiration*. The act of inspiration is provided for in a more especial manner than the act of expiration. It requires more muscular effort, and is more essential to life. Inspiration is the first act of resuscitated life, the last of exhausted nature, and for this reason the muscles of inspiration are large and powerful, and the nerves in a double order, for not only do the lateral branches of the spinal marrow influence the act of inspiration, but these additional respiratory nerves descend from the upper part of the spinal marrow to the chest, as an additional and especial provision, guarding life.

accompanied with corresponding actions of the sternal portions of the muscles in the neck.

When a man suffers fracture of the spine at the sixth cervical vertebræ, and the marrow is crushed, he continues to breathe by the influence of the three nerves which arise above the injured portion. He inspires with force; but he cannot perform expiration by muscular effort, it is only by the elasticity and gravitation of the parts. He can yawn, for that is an action of drawing the breath; but he cannot sneeze, for that is an action of expelling the breath. But this is a subject so curious in itself, and which has hitherto been considered so carelessly, that I shall reserve it for a distinct dissertation.*

A man having a complete hemiplegia, the side of his face relaxed, the arm hanging down powerless, and the leg dragged in walking, we were curious to know if the influence pervaded all the nerves of the side, or only the regular or voluntary nerves. Some trouble was taken to make him heave up the shoulder of the debilitated side, but to no purpose. He could only do it by bending the spine to the other side, and as it were, weighing up the paralytic shoulder. But on setting him fairly in front, and asking him to make a full inspiration, both shoulders were elevated at the same time that both the nostrils were in motion. The respiratory nerve of the face, and the superior respiratory nerve, were entire in their office; and, although the regular system of nerves refused acting, the *sternomastoideus* and the *trapezius* partook of their share in the act of respiration. Seeing that the mastoid muscle has two sets of nerves, that one of these is of the class of voluntary nerves, and the other of respiratory nerves, are we not borne out in concluding, that when the head is moved, being a voluntary act strictly, it is performed through the common class of voluntary nerves? that when the chest is raised, it is an act of respiration, and is effected through those nerves which controul the muscles in respiration?

This conclusion is confirmed by the following experiment. In the ass, there are two muscles which take the office of the mastoid muscle; one is inserted into the jaw, which we may call *sterno-maxillaris*, and the other into the vertebræ, viz. *sterno-vertebralis*. To these the superior respiratory nerve (or spinal accessory) is distributed in its passage to the trapezius. These muscles are at the same time supplied with numerous nerves directly from the spinal marrow. If we expose the superior respiratory nerve, and then induce excited respiration, so as to bring these muscles into powerful action in combination with the other muscles of respiration, and if, while this action is performed, we divide the nerve, the motion ceases, and the muscle remains relaxed until the animal brings it into action as a voluntary muscle.

An ass being thrown, its phrenic nerves were divided, on which a remarkable heaving of the chest took place. It rose higher, and the margins of the chest were more expanded at each inspiration. There was no particular excitement of the muscles of the neck, shoulder, or throat, at this time; so that to excite the actions of these muscles it was necessary to compress the nostrils. When they began to act with more violence, keeping time with the actions of the other muscles of respiration,

* See the observations, p. 179.

the superior respiratory nerve was divided; immediately the action ceased in the muscles attached to the sternum of the side where the nerve was divided, while the corresponding muscles of the other side continued their actions.

After dividing the spinal marrow between the vertebræ of the neck and those of the back, respiration is continued by the diaphragm: which experiment, as it is often mentioned by physiologists, the author has not thought it necessary to repeat, but only to institute the following experiment on an ass. The phrenic nerves being first divided, and then the spinal marrow cut across at the bottom of the cervical vertebræ, respiration was stopped in the chest; but there continued a catching and strong action at regular intervals in the muscles of the nostrils, face, and side of the neck. The main part of the apparatus of respiration was stopped, but these accessory muscles remained animated, and making ineffectual endeavours to perform the respiration. When apparent death had taken place, the ass was re-animated by artificial breathing, and then these muscles on the face and neck were restored to activity, and became subject to regular and successive contractions, as in excited respiration, whilst the chest remained at rest. These actions continued for a short time, and then ceased, but upon artificial respiration being again produced, the same results followed. This was repeated several times; the animal remaining insensible during these experiments.

Upon stimulating the nerves after the death of this animal, it was observed, that the class of respiratory nerves retained their power of exciting their respective muscles into action, long after the other nerves had ceased to exert any power; they were evidently of that class which retain their life the longest.

It is a duty to avoid the unnecessary repetition of experiments, and I have now to make a short statement of facts, resting on the highest authorities: experiments made without reference to the conclusions which I am now to draw.

The division of the recurrent branch of the *par vagum* destroys the voice.*

The division of the laryngeal branch of the *par vagum* stops the consent of motion between the muscles of the *glottis* and the muscles of the chest.†

The injury or compression of the *par vagum* produces difficulty of breathing.‡

By the assistance of these well-known facts, we complete the knowledge of the circle of actions which result from the respiratory nerves.

The *medulla oblongata* and *spinalis* are composed of columns of nervous matter, and from the different powers of the nerves, as they arise from the one or other of these columns, it is proved that they possess distinct properties. In animals that breathe by ribs and a numerous class of muscles, and which animals have a spinal marrow, we see that a

* Sectis ambobus nervis recurrentibus vox perit: *Arnemann, Sœmmerring, Morgagni.*

† *Le Gallois.*

‡ Vinculo compressis nervis vagis oriuntur in bestiis spirandi difficultas, surditas, vomitus, corruptio ciborum in ventriculo. *Sœmmerring, Haller, Brun de ligaturis nervorum.*

column of nervous matter is embraced between the anterior and posterior *virgæ* of that body, and that this portion may be traced downwards between the roots of the spinal nerves. From the upper part of this column, where it begins in the *medulla oblongata*, the several nerves proceed which have formed the subject of these papers, and on the influence of which, it has been proved, the motions of respiration principally depend. It is not an extravagant conclusion to say farther, that the power of the regular succession of intercostal and lumbar nerves, as far as they regulate the respiratory actions, proceeds from the connections of the roots of these nerves with this column, which is continued downwards, and which can throughout be distinguished from the rest of the spinal marrow.

We are now enabled to distinguish the influence of the spinal marrow, and its regular succession of nerves, from those which have been traced in these papers. The first are essential to the act of respiration; without them the others are unequal to the task. But on the other hand, although the regular succession of spinal nerves be equal to the raising and depressing the thorax, they are not equal to the full heaving of the chest in animated exertion of the voice. They are not competent to the performance of the motions of the glottis, pharynx, lips, and nostrils, which several parts are necessarily influenced in excited respiration, as well as in the acts of smelling, coughing, sneezing, and speaking: for these, the co-operation of the whole extended class of respiratory nerves is required.

Surveying the complicated machinery which in man is prepared for these various offices, we may reap the benefit of these fatiguing details, in the contemplation of the most interesting phenomena in nature. The relations of the subject may be presented under the heads of Pathology, and Expression.

ON THE ACTIONS OF RESPIRATION IN THOSE WHO HAVE SUFFERED FRACTURE OF THE SPINE AT THE LOWER CERVICAL VERTEBRÆ.

When the spinal marrow is crushed at the upper part of the spine, the man dies instantly; but if the spinal marrow be crushed opposite to the lower part of the neck, although the injury be such as to deprive him of all sense and all voluntary motion of the parts below, he continues to breathe.

It has been stated by our first authorities, that a man in these circumstances breathes by his diaphragm, in consequence of the phrenic nerve, which supplies that muscle, taking its origin from the spinal marrow above the part injured. But the observations have been inaccurately made which have led to this opinion. I shall first show how untenable such a supposition is, and then detail the phenomena which attend the fracture of the spine at this part; and, finally, show that other nerves besides the phrenic descend from the same source to supply the exterior muscles of the chest, and that it is in part through their influence the act of respiration is continued.

The diaphragm is that muscular septum which divides the thorax and abdomen, and by the descent of which the depth of the cavities of the chest is increased in inspiration. When it has acted and descended,

and the air is admitted into the lungs, that air is again expelled by the re-action of the abdominal muscles. These muscles compress the viscera; and, by pushing them up, raise the relaxed diaphragm, preparing it for another effort of inspiration. Is it not obvious, that if the power of the diaphragm remains entire, and the power of the abdominal muscles be lost, that the respiration must stop? It would be so, were it not that there are other muscles and other nerves no less important than the diaphragm and the phrenic nerves, and which physiologists have not contemplated.

In the first part of this paper it is shown that the *sterno-cleido-mastoideus*, the *trapezius*, and the *serratus magnus*, are muscles calculated, by their combined operation, to raise the chest with great force, and to perform inspiration. It is also shown that the nerves there described as the superior and the external respiratory nerves, take their course exclusively to those muscles which act upon the chest; and that what the phrenic nerves are to the diaphragm, these are to the three great exterior muscles. It is further shown by what has preceded, that as all these nerves take their origins from the same part of the spinal marrow, they are consequently in the same circumstances as to fracture of the spinal tube. When the spine is fractured at the lower cervical vertebræ, these nerves escape injury, and continue to animate the muscles exterior to the ribs as well as the diaphragm.

The great importance of these exterior nerves and muscles to the continuance of life will be proved by the following cases. I have purposely omitted all the detail of practice, and have taken the symptoms purely in a physiological view, and as if it were an experiment instead of a most afflicting accident to a fellow creature.

Within the space of one month these three instances of fracture of the vertebræ of the neck have occurred in my practice. In one instance, the bones were broken at the lower part of the neck, and the patient lived some days. In the second instance, the vertebræ of the neck were fractured in the middle of the neck, and the man lived half an hour. In the last instance, the uppermost vertebra was fractured, and the death was immediate.

Case I.—*Percy Ward*, 29th May.—Charles Osborne, ætat. 26.—On Saturday evening this man was putting pulleys into a window-sash, when the small steps on which he stood slipped from under him, and he was precipitated through the window into the area, a height of 13 feet. He thinks he fell upon his back; but he is uncertain, as he lay for some time senseless. He lies now in bed, supine and powerless, but describes the part injured to be the spine betwixt the scapulæ. As we desired to have only the essential feature of this case, it is better to say at once that this was a deception, that he felt the pain of the injury at a point considerably lower than the fracture, and that on his death it was discovered that the arches and bodies of the sixth and seventh cervical vertebræ were broken.

The lower extremities are motionless and insensible. He can raise his shoulders and bend his arm, but over the motion of the hands he has no power.

Another report adds,—his expression is singular; he says he can

move his arm by the strength of his shoulders, which is exactly true, for by moving the shoulder he can give a certain rotatory motion to the humerus, and consequently move the fore-arm when it is bent at the elbow. The skin of the arms, however, retains its sensibility to the point of a pin. The abdominal muscles are relaxed, and the viscera feel flaccid. He can make no effort to expel the urine; his urine is drawn off by the catheter, and his fæces pass involuntarily: there is priapism. When I induce him to attempt an effort and to strain, no change on the abdominal muscles can be felt; there is no firmness or rigidity in them. The integuments of the abdomen and of the chest, as high as the nipples, are insensible.

His breathing is frequent, and at each inspiration the chest is heaved with a short and quick movement; at each expiration the abdomen is protruded with a sudden shock and undulation. The belly, during this effort of breathing, is uniformly soft and full: and when drawn in. it is by the elevation of the ribs; and when the chest falls, it is protruded.

He has been observed to yawn naturally. Query, Can he cough?

An examination has been made to-day to answer this query. When he is asked to cough, he pulls up the ribs and extends the chest, and lets them fall: he coughs, but not strongly: it is obviously by his power of raising the chest and giving elasticity to the ribs, and by the weight of the parts falling, that he is enabled to expel the breath. He cannot divide the expiration into two coughs, nor give two impulses to the air; but each time he coughs the elevation of the chest must precede it.

On spreading the hands and fingers on the side of his chest the action of the serratus muscle could be felt, and also the lower margin of the trapezius muscle was felt to become firm during the act of inspiration, as when he prepared to speak.

Being asked if he had sneezed by any chance, his answer was—"No, sir; I cannot blow my nose." This was not that he could not raise his hand to his head: he was conscious of wanting the power of forcibly expelling the air. Mr. B., taking a handkerchief from a nurse, and holding the patient's nose as a woman does a child's, the patient could not blow the nose; he could not give that sudden impulse of expiration which is necessary.

In one of the reports of this case it was stated that the patient was disturbed by horrible dreams. This is very likely, from the respiration being in part obstructed; but I omitted to verify that observation during the patient's life.

It is remarkable in this case, that on feeling his stomach, he, of his own accord, marks the difference of sensibility, internal and external. He says he feels internally, but he does not feel on his skin. He feels me when I press the stomach, and has complained of the griping from his medicines. Another instance proving that the par vagum is a compound nerve.

This man died in the night of the seventh day from the accident. The night nurse gave no particular description of the manner of his death, further than that he seemed to desire to speak and could not: he made attempts to articulate, but could not.

Case II.—James Saunders, ætat. 45, June 30.—This man fell only

four feet, but he fell backwards, and struck his neck against an iron railing. The transverse processes of the fifth and sixth cervical vertebræ were found fractured; and there was diastasis of the articulations between these vertebræ. The body of the sixth vertebra was fractured. The spinous processes, also, of the fourth and fifth vertebræ were found fractured at their bases.

The house surgeon reports of this man, that when he was brought into the hospital he was perfectly sensible; that his face indicated great alarm and anxiety. Every time he drew his breath, it was attended with an effort to raise the shoulders, and a contraction of the muscles of the throat: every time he breathed, his head appeared to sink beneath his shoulders. On putting his hand on the pit of his stomach no motion of the viscera of the abdomen could be perceived. He had no feeling even in the upper part of his chest: he had feeling on his face and neck, and indistinctly near the collar bone. He had a motion of his hands, a sort of rolling motion, which may have proceeded from the shoulders. When he spoke, it was in a tremulous voice, like a man frightened: his voice was weak, but he did not speak in a whisper: the sound of his voice was more like sighing than common breathing. Pulse was felt at his wrist. In ten minutes after he was brought in, half an hour from the time of the accident, he died.

Case III.—On the following day a man was brought into the hospital dead. He had fallen fifty feet, and had lighted on the ground upon both his shoulders. By the accounts of the men who carried him to the hospital, he appears to have been instantaneously killed. The dissection sufficiently proved that he was killed suddenly: for, besides extensive fracture and injury to the lower part of the spine, the atlas and dentata were found likewise fractured. The tooth-like process of the vertebra dentata was broken through just at its base. It was separated completely, and was found embraced by the transverse ligament in its natural situation upon the atlas. The arch of the atlas was partially fractured on each side; and a portion of its body, where the process of the dentata rolls upon it, was also fractured and detached.*

* A young man was brought into the Middlesex Hospital, who had fallen upon his head. He soon recovered, and lay for some time in the hospital without exhibiting a symptom to raise alarm. He had given thanks to the assembled governors of the hospital, and had returned into the ward for his bundle, when, on turning round to bid adieu to the other patients, he fell, and in the instant expired. Upon examining his head, it was found that the margins of the occipital hole had been broken: no doubt it had happened that in turning his head the pieces were displaced, and closed and crushed the medulla oblongata, as it passes from the skull.

A man was trundling a wheel-barrow in Goodge Street, which is immediately adjoining the Middlesex Hospital: in going from the carriage-way to the flag-stones he met the impediment of the curb-stone. He made several efforts to overcome it; and at length, drawing back the wheel-barrow, he made a push, and succeeded; but the wheel running forward, he fell, and remained motionless. He was taken into the hospital, but he was found to be quite dead. The tooth-like process of the second vertebra of the neck had burst from the transverse ligament of the first. The impulse given to the head had done this violence, and had at the same time carried forward the spinal marrow against the process, and on which it was crushed.

These cases occurred before my time, but I have had two instances of sudden death from the dislocation of the atlas from the second vertebra of the neck. In short, the fact is perfectly well ascertained.

In the above narratives we have the account of those symptoms which accompany fracture of the cervical vertebræ, and which have hitherto been negligently considered, from an entire want of interest in the subject. It appeared to me very distinctly, that, in the case first described, the man had the power of drawing his breath by muscular exertion; but that the expulsion of the breath was not a muscular effort, but occasioned entirely by the elasticity of the ribs, and the gravitation of the parts forcibly raised by the action of the muscles. This was evident, in the total want of the power to exert the abdominal muscles, or to compress or depress the chest above its condition of rest; in the necessity of raising the chest at the utterance of each word; in the perfect power of yawning, which is a gradual and powerful act of inspiration; in the want of the power of sneezing or blowing the nose, which is a sudden call of the muscles of expiration into action.

The strongest reason of all for this view of the use of these nerves, which I have called respiratory, is, that respiration and the activity of the muscles of the chest did actually continue after the functions of the spinal marrow were destroyed by violence done to the tube; and that there is no other explanation of the fact than this, that those nerves which take their origin from the medulla oblongata and upper part of the spinal marrow, and which descend upon the neck and chest, did continue to animate the sterno-cleido-mastoideus and the trapezius, and the muscles of the throat, in the act of inspiration. We have only further to recollect, that it was not the forcible, occasional, and voluntary motions of respiration that were thus preserved, but that by the same means, viz. the superior, the external, and the phrenic nerves, the play of the chest in respiration during sleep was continued.

In the second case, it is clearly proved, both by the symptoms and the dissection of the bones, that the fracture must have affected the roots of the phrenic nerves; and we are at liberty to conclude, that the difference of symptoms, in comparing it with the first case, as well as the shorter period of his sufferings, was owing to this cause.

The manner of breathing was very different, and is described by our house surgeon* in a manner to produce conviction. *His breathing was like sighing*; and at each inspiration his head was drawn betwixt his shoulders. That is to say, that by the loss of the action of the diaphragm the action was thrown on the muscles exercised through the spinal accessory nerve, and this is confirmed by what is said of the want of motion in the viscera of the abdomen; for, as it was proved in the first case, at each contraction of the diaphragm the viscera of the abdomen are propelled outward.

The want or defect of action in the diaphragm, and the action of breathing being circumscribed to the muscles of the neck and shoulders, were undoubtedly the cause of the patient sinking so soon.

In the last case, it appears, the spinal marrow being injured so high up as to destroy the roots of all the respiratory nerves, the death was sudden, as in pithing an animal.

When we have ascertained these facts, certain queries are naturally suggested. Why should these respiratory nerves, which descend from

* Mr. Turner.

above upon the thorax, go only to muscles which assist in raising and expanding the chest? Why should the act of inspiration be secured by a double provision of nerves, viz. those which come out from the sides of the spine, and those which descend from the neck, when the act of expiration is provided for solely through the former?

I would offer these reasons:—

First. The act of drawing the breath is the more difficult, and requires the more force; the act of expiration is comparatively easy, being assisted by the weight of the parts incumbent on the ribs, as well as the resiliency or elasticity of the ribs themselves.

Second. The act of inspiration is the active state; the condition of expiration is a state of rest.

Third. The inspiration is necessary to life, and must be guarded with more care, and performed with more force than the expiration. In one suffocating, the agony is in elevating the chest and drawing the breath. On the approach of death, the inspiration becomes more laboured, that is, the exterior muscles are in violent action; but the act of expiration is an interval of rest.

Fourth. These nerves, which govern the muscles of inspiration, are linked more intimately by sympathy with the state of circulation and respiration; for we see in disease, as in experiments on animals, that when the powers of life have run low, the sympathy is still exerted with such sudden catching of the muscles of inspiration, and with an effort so powerful and unexpected, as to startle, while the expiration is soft and without effort. We perceive the same sympathy causing the same sudden and powerful inspirations, and marking the presence of life, when a person is recovering from fainting, or from suspended animation, from whatever cause; as drowning, hæmorrhage, &c. The sudden inspiration is always the first of the renewed actions of life, as it is the last in exhausted nature.

This corresponds with the experiments made on animals. When the sensibility is exhausted in the common spinal nerves, from the ebbing of life, the respiratory nerves on the neck and side of the chest are still capable of exciting the muscles to renewed vibrations; they are the last to die.

These considerations exhibit the importance of the act of inspiration over that of expiration, and prove the necessity for these exterior nerves of respiration.

We have seen, by experiments, that the respiratory nerves are distinguished from the other nerves by retaining their power longer: that they are alive to impression, and can be made to produce convulsions in the muscles they supply, after the other nerves are dead to the application of stimuli. In disease, during the oppression of the mental faculties, and on the approach of death, we witness these nerves, and the muscles put into operation by them, continuing their functions, when in other respects the body is dead. This circumstance, so familiar to the medical observer, might have led to the conclusion to which we have arrived, more laboriously, through anatomical investigations—that there are a great many muscles extended over the body, and which perform the common offices under the will, which are occasionally drawn into combination with the muscles of respiration, and are held in relation to the

vital functions by a distinct system of nerves, and that these nerves have a centre and a source of power different from that of the voluntary nerves.

SOME FURTHER REMARKS ON THE PATHOLOGY OF THE RESPIRATORY SYSTEM OF NERVES.

When we survey the full extent of the respiratory system of nerves, we are prepared to comprehend its importance to the continuance of life. The infant born without a brain can breathe if the origins of these nerves be entire. Deep wounds of the brain, though eventually fatal, are not necessarily, or instantly so. The man wounded in the spine, below the origins of the nerves which we have traced, drags on existence for a few days; but a bruise on the part of the *medulla oblongata* from which these nerves take their departure, is death in the instant; a breath is not drawn again.

In describing the effects of violence on the medulla oblongata, authors have attributed the sudden death to injury of the roots of the nerves of the par vagum; and yet we have a statement from the same authority, that an animal will survive the division of both nerves of the par vagum. Now that we find that many respiratory nerves depart from the same centre, and go out to all the parts of the muscular frame which move in respiration, we can better comprehend how injury of the medulla oblongata suppresses at once the act of respiration in the nostrils, throat, and windpipe, as well as the action of the muscles both without and within the chest; even the expression of the agony of dying is, by the injury of the roots of all these nerves, suddenly interrupted, and actual death follows quickly, owing to the cessation of the respiratory functions.[1]

The first thing that strikes us is the vital character of these nerves called respiratory; that as they form a system belonging to the heart, lungs, stomach, larynx, throat, and the whole exterior association of muscles of respiration, they must be essential to life, and influenced in all mortal affections; and that, in fact, death cannot take place whilst this division of the nervous system is unchanged or unaffected. On the contrary, the injury to their function is attended with immediate death, and the change takes place with appalling suddenness; not a breath is drawn, nor a word uttered, nor a struggle to indicate pain, nor a feature discomposed.

On the contrary, if other parts of the body are injured by disease or accident, death comes slowly from the rising of inflammation, or the extension of the influence slowly over the system; at length the respiratory system partakes of the influence, the chest rises higher and more frequently, an alarming symptom, when there is reason to fear approaching dissolution; the throat is then affected; the whole apparatus of respiration is violently agitated; the chest, neck, lips, and cheeks, and eyeballs are wrought with terrible convulsions; the breathing is about to stop; the action returns with sudden and startling effort, and then ceases; the patient dying in the state of expiration, the muscles of inspiration being incapable of renewing their effort.

If it be important to know the approach of danger, and to distinguish

betwixt nervous agitation from the formidable symptoms of approaching dissolution, it is necessary to know the causes of these symptoms, otherwise the physician is no better than the nurse.

It must happen that the derangement of one part of this class of important organs must affect the other. The stomach, for example, as the most abused in its office, is daily exhibiting the effect of its close alliance with this system of nerves ; and what we learn from this anatomy of the respiratory system is, that the stomach stands in close connection with the respiratory nerves, and that an irritation on the stomach will have all the effects of an injury immediate upon the lungs.

The stomach, heart, and lungs are undoubtedly the seat of that affection which is attended with sudden death ; when there are no tokens or symptoms in the agitations of the respiratory organs, the source from which danger is to be most apprehended is the stomach ; and founding on the fact expressed above, I have to suggest, that it is the duty of the patient to struggle against the increasing influence of the stomach on the condition of the respiratory organs : that the physician has not merely to regulate the stomach as the organs of digestion, but that the patient has to study to preserve his freedom of respiration against the prevailing influence of the stomach.

One of our athletæ out of training is pursy, breathless, and cannot bear the buffets, shocks, and falls to which he is liable in a bruising bout. But by spare and healthful diet, regular severe exercise, mimic combats, in which his breast, belly, and head are repeatedly buffeted, he is at length capable of standing under shocks that would be fatal to a man of equal strength and better constitution, but otherwise unprepared for what he is to undergo. Whether it be an effort of the body, or of the constitutional strength ; whether it be an exertion of the head, or hands, or feet, we must come to the full exercise gradually and by slow degrees. Thus I argue the matter with a man whose palpitations are excessive and painful, on every accelerated step ; he must not altogether avoid the occasion which gives him uneasiness, but by encountering them repeatedly, and by slow degrees, familiarize himself with the exertion.

As these nerves belong to a distinct system, and have a different origin from the nerves of sensibility and common muscular motion, so it is fair to presume that they will occasionally be affected by disease, when the others are left in a natural and healthy condition. But if the natural distinctions of the nerves be negligently considered, the affection of the respiratory nerves must remain obscured. I have already had occasion to remark, that the portio dura, or respiratory nerve of the face, is very subject to derangement, producing partial paralysis, or frequent and spasmodic twitchings of the face. The most frequent defect proceeding from this cause is a rapid and twinkling motion of the eyelid of one side. Sometimes we find the whole of one side of the face subject to contractions, by which the features are drawn towards the ear. This condition of nerves, and consequent spasmodic muscular contractions, sometimes extends to the neck ; then we see the head suddenly twitched sideways, at the same moment that the mouth is drawn aside. This is a great deformity ; for while the individual is animated and speaking with exertion, he gives those sudden startling motions, opening his mouth and turning it to his shoulder, as if he were catching flies. The

neck is twisted, the head bent down, and the mouth turned laterally and opened. These motions must now be attributed to the influence of the respiratory nerves of the face and neck.

But the same class of nerves, in their distribution to the chest, are subject to the same derangement. It is not very uncommon to find the shoulder of a young person falling low, and the appearance of distortion produced by a paralysis of that part of the trapezius muscle which supports the shoulder, and which is supplied by the spinal accessory nerve. This affection forms a parallel with the paralysis of the eyelid and the cheek; and there are not wanting examples of spasmodic affection of the thorax resembling those which I have just noticed on the side of the face and neck.

We perceive that these nerves of respiration, so peculiar in relation and function, are differently influenced by disease from the other division of the nervous system. We know that their functions are left entire when the voluntary nerves have ceased to act; and they are sometimes strangely disordered, while the mind is entire in all its offices, and the voluntary operations perfect. In tetanus the voluntary nerves are under influence, and the voluntary motions locked up in convulsions; in hydrophobia, on the contrary, the respiratory system is affected; and hence the convulsions of the throat, the paroxysms of suffocation, the speechless agony, and the excess of expression in the whole frame, while the voluntary motions are free.

The confusion between vital and voluntary nerves, the combining the par vagum and sympathetic nerves together, and the exclusion of the *portio dura* of the seventh nerve, the spinal accessory nerve, and the external thoracic nerve, from their natural classification with the diaphragmatic or phrenic, has given rise to very vague theories, and occasioned very inaccurate statements of pathological facts.

The frequency of sudden death, where no corresponding appearances are exhibited in the brain or heart, leads us to consider more attentively the only part of the system through which life can be directly extinguished. In *angina pectoris* we witness the agony of suffering in this system when the patient survives; and when he dies suddenly, we can imagine it to proceed from an influence extending over these nerves, and interrupting the vital operations. We have seen that a branch of this system may suddenly cease to operate on the corresponding muscles, and that in this way the side of the face may be deprived of all participation in the act of respiration, and all expression be lost. What would result from a more universal defect in the actions of this class of nerves but sudden death?

The stomach, supplied with the great central nerve of this system, exhibits the most powerful influence on these extended nerves; a blow on the stomach "doubles up" the bruiser, and occasions that gasping and crowing which sufficiently indicates the course of the injury: a little more severe, and the blow is instantly fatal. A man broken on the wheel suffers dreadful blows, and his bones are broken, but life endures; the *coup de grace* is the blow on the stomach.

The position of the asthmatic shows how this system is affected; whether directly or indirectly, it is not our present business to enquire. He stands stooping forward, resting his arms so as to throw the muscles

of the chest into operation upon the ribs. The position of the head and the rigidity of the muscles of the neck, the action of the mastoid muscle, and of the cutaneous muscle, visible in the retraction of the cheeks and mouth, and the inflation of the nostrils, carry us back in review of the nerves and muscles of respiration.

It will now, perhaps, be acknowledged, that the methods of physiologists, in accounting for the combination of parts in the actions of respiration, were very imperfect, or rather altogether erroneous. To account for the convulsion of the diaphragm in sneezing, they were constrained to go a far way about: first, connecting the roots of the phrenic with the sympathetic nerve: bestowing sensibility on the latter, which it does not possess: then, following a remote connection between it and the nerves of the nose; then again, counting the relations between the facial nerve and the third of the neck: they satisfied themselves that they had explained the manner in which the diaphragm became convulsed upon irritating the membrane of the nose. Another misconception was engrafted on the first; they spoke of these actions as convulsive and irregular, which are amongst the most admirable provisions for the protection of life. As to the act of sneezing; like coughing, it is a consequence of an irritation of the extremity of one of the respiratory nerves, whence the whole muscles of respiration are brought into action. That there is nothing accidental, nor of the nature of convulsion, is shown by the admirable adjustment of the muscles to the object. A body irritating the glottis will call into simultaneous action the muscles of respiration, so as to throw out the air with a force capable of removing the offending body. But if the irritation be on the membrane of the nose, the stream of air is directed differently, and, by the action of sneezing, the irritating particles are removed from these surfaces. By the consideration of how many little muscles require adjustment to produce this change in the direction of the stream of air, we may know that the action is instinctive, ordered with the utmost accuracy, and very different from convulsion.

OF SMELLING, AS INFLUENCED BY THE PORTIO DURA OF THE SEVENTH NERVE.

It will, I hope, be acknowledged that I have studied the functions of the parts to which the nerves are sent, before I made my experiments or drew my conclusions. Even in the exercise of the sense of smelling, parts are employed, which do not, at first, seem necessary. For the highest enjoyment or exercise of the sense of smelling, it is necessary that the stream of air inhaled through the nostrils should change its direction, and be increased in force. In breathing through the nose, the air is carried directly backward. If the nostrils are expanded in anxious or hurried respiration, the passage is enlarged, and made more direct. But, perhaps, my reader is not aware that in each nostril there are two circular openings, the innermost something more than half an inch within the other. This interior circle expands, and becomes lower when the breath is forcibly drawn into the lungs; but in the act of smelling it is

much diminished and elevated. The change in the form and relation of the exterior and internal nostril is performed by the action of the muscles on the cartilages; and the effect of the change is to increase the force of the stream of air, and to direct it up towards the seat of the sense of smelling. In common breathing some part of the effluvia afloat in the atmosphere reaches the seat of the sense; but fully to exercise the sense, it is necessary to concentrate and direct the stream of air, as I have described.

It will now be comprehended how the destruction of the *portio dura*, or respiratory nerve of the face, affects the organ of smelling; for if by the injury of that nerve the motion of the muscles of the nostrils be lost, the breath may be drawn into the lungs through the relaxed passage, but it will not be drawn forcibly up towards the seat of the olfactory nerve, nor will the air brush over the surface on which the proper nerve of sense is expanded.

A man being paralytic on one side of the face by the loss of power in the *portio dura*, he was made to smell ammonia: it did not affect the paralytic side, because it was forcibly inhaled into the cells of the nose only on the side where the nostril was moveable. On trying the experiment on a dog, in whom the *portio dura* of one side had been cut, the same thing was manifested; he snuffed it up with the sound side, and showed the natural consequence of the irritation of the membrane; while he was not similarly affected when the bottle was put to the paralytic nostril.

Unless I had attended to the structure and function of the part, on witnessing these phenomena, I might have conceived that the seventh nerve was the nerve of smelling, like a noted French physiologist, who concluded too hastily, that he had discovered the nerve of vision and of smelling in the fifth nerve.

I allude to certain experiments lately performed in London by a distinguished visitor, which afford a proof of the utter impossibility of reasoning correctly on these subjects without the knowledge of the anatomy. The olfactory nerve was destroyed, and ammonia put to the nostrils of the animal, and when the creature sneezed, it was a *coup de théâtre!* then the gentlemen congratulated themselves that it was discovered that the first pair of nerves was of no use!! The common irritability of the Schneiderian membrane results from the fifth nerve: why does the membrane possess this sensibility, and why is the sensibility joined to the actions of the respiratory system? because these passages must be guarded as the larynx is guarded. When any thing offensive is lodged there, it must be removed; and the means nature employs is, to drive the air by an instinctive action of the respiratory organs, violently and suddenly, through the nostrils. But what has this to do with smelling? As well might we destroy the olfactory nerve, and wonder that the creature experimented on still coughed when the larynx was tickled.

We have some observations on this subject in Mr. Shaw's paper already quoted. "The effect upon the nostril is the most obvious symptom, when the nerve is cut in the ass. If after having cut the right nerve, (*portio dura*) we hold the nostril for a short time, so as to prevent the animal from breathing, he will, when freed, begin to snort, but with

the left nostril only. If we hold carbonate of ammonia to the paralysed nostril, he will not be affected; but if it be held to the other, he will snuff it up, and then curl the nostril, and have an expression in the whole of that side of the face, as if he were going to sneeze, while the right side will remain quite unmoved."

The rationale of this is worth attention; by the neglect of it some physiologists and experimenters have appeared to much disadvantage. The act of smelling is not simply the act of drawing the breath; but while the breath is drawn there is a conformity in the motion of the nostrils, by which the air, loaded with the effluvia, is directed to the seat of the olfactory nerve; that is to say, is made to circulate in the higher parts of the cavities of the nose, instead of streaming directly backwards into the posterior nostrils. This was the reason why, on putting the ammonia to the nostril which was still, the creature was not excited, although there had been nothing done to injure the sensibility of that side of the nose. If a man were simply to draw his breath in taking snuff, the powder would be drawn into his fauces and lungs: but to snuff, the point of the noise is drawn down, and the nostrils contracted; and then, when the air is inhaled, the snuff rises to the superior cells, and stimulates all the interior of the nostrils. Although by this stimulus he sneezes, the olfactory nerve has nothing to do with it. The luxury is in the stimulus of the respiratory system through the excitement of the membrane, not in the odour as enjoyed by the olfactory nerve. The sensitive branches of the fifth are first excited, then the respiratory system is in a secondary manner affected; and to ascertain whether the mode of communication between the fifth and the respiratory nerves be affected at their roots in the brain, or at their extremities, is a fair question to be determined by experiment or reasoning.

THESE RESPIRATORY NERVES ARE ORGANS OF EXPRESSION.

We may notice another office of these respiratory nerves; in smiling, laughing, and weeping, the influence is solely propagated through them. The face, we have seen, is dead to all changes of the kind when the nerve of this class which goes to it is destroyed, whether it be by division of the nerve, or from its being surrounded with inflammation or suppuration. When we consider that all the respiratory nerves depart from the same source, and participate in the same functions; and, more especially, when we see the respiratory organs so very distinctly affected in the conditions of the mind which give rise to these affections, it is not too much to suppose, that what is proved in regard to one of these nerves, is true of the whole class, and that they alone are influenced in laughter. Physiologists who have not investigated the cause, are yet agreed in describing laughter to be a condition of the respiratory muscles, where the air is drawn in rapidly, and thrown out in short spasmodic motions of these muscles; that crying is nearly the reverse, the inspiration being cut by spasmodic actions of the muscles of inspiration. By these considerations are explained the *subrisus* which arises from abdominal irritation, and the sardonic retraction of the muscles of the face produced by wounds of vital parts, and particularly of the diaphragm. It explains

also the successive convulsive lifting of the shoulders in wounds of the diaphragm.

That a system of nerves so intimately combined as this is with the other parts of the general system, should suffer in hysterical disorders, cannot surprise us; and, admitting that irritation reaches to the respiratory system, we may perceive how rapidly the change may be produced, from the convulsions of laughter to those of crying; and where, if there be a corresponding condition of the mind, it rather follows than precedes the expression of the frame.

It would have been extraordinary if we had arrived at any satisfactory theory of expression, before it was known through what instruments the mind influenced the body during emotion or passion. But since we know that the division of the respiratory nerve of the face deprives an animal of all expression, and that the expressive smile of the human face is lost by an injury of this nerve; since it is equally apparent that the convulsions of laughter arise from an influence extended over this class of nerves; it comes to be in some sort a duty, in pursuing this matter, to examine farther into the subject of expression. We may be at the same time assured of this, that whatever serves to explain the constant and natural operations of the frame, will also exhibit to us the symptoms of disease with more precision.

In terror, we can readily conceive why a man stands with eyes intently fixed on the object of his fears; the eyebrows elevated, and the eyeballs largely uncovered: or why, with hesitating and bewildered steps, his eyes are rapidly and wildly in search of something. In this we only perceive the intent application of his mind to the objects of his apprehensions, and its direct influence on the outward organs. But when we observe him farther, there is a spasm on his breast: he cannot breathe freely: the chest remains elevated, and his respiration is short and rapid: there is a gasping and convulsive motion of his lips: a tremor on his hollow cheeks: a gulping and catching of his throat: his heart knocks at his ribs, while yet there is no force in the circulation; the lips and cheeks being ashy pale.

It is obvious that there is here a reflected influence in operation. The language and sentiments of every people have pointed to the heart as the seat of passion, and every individual must have felt its truth. For though the heart be not in the proper sense the seat of passion, it is influenced by the conditions of the mind, and from thence its influence is extended through the respiratory organs, so as to mount to the throat, and lips, and cheeks, and account for every movement in passion which is not explained by the direct influence of the mind upon the features.

So we shall find, if we attend to the expression of grief, that the same phenomena are presented; and we may catalogue them, as it were anatomically. Imagine the overwhelming influence of grief—the object in the mind has absorbed the powers of the frame; the body is no more regarded, the spirits have left it; it reclines, and the limbs gravitate; the whole body is nerveless and relaxed, and the person scarcely breathes: so far there is no difficulty in comprehending the effect in the cause. But why, at intervals, is there a long drawn sigh, why are the neck and throat convulsed, and whence the quivering and swelling of

the lip; why the deadly paleness, and the surface earthy cold; or why does convulsion spread over the frame like a paroxysm of suffocation?

To those I address, it is unnecessary to go farther, than to indicate that the nerves treated of in these papers are the instruments of expression, from the smile upon the infant's cheek to the last agony of life. It is when the strong man is subdued by this mysterious influence of soul on body, and when the passions may be truly said to tear the breast, that we have the most afflicting picture of human frailty, and the most unequivocal proof that it is the order of functions which we have been considering that is then affected. In the first struggles of the infant to draw breath, in the man recovering from a state of suffocation, and in the agony of passion, when the breast labours from the influence at the heart, the same system of parts is affected, the same nerves, the same muscles, and the symptoms or characters have a strict resemblance.

Having examined the system of nerves and muscles, which are the agents in respiration, in their fullest extent and in all their bearings; having looked at them in their highest state of complication in the human body; and having traced them upwards, from the animals of simple structure, and then by experiment, and in a manner analytically as well as synthetically; their relations become obvious. Instead of one respiratory nerve, the *par vagum*, the nerve so called, is found to be the central one of a system of nerves of great extent. Instead of the relations of the vital organs of circulation and respiration depending on some supposed influence of the sympathetic nerve, they are found to have an appropriate system.

This system of nerves, extricated from the seeming confusion in which it lay hitherto encumbered, is found to be superadded to that of mere feeling and agency, attributes common to all animals: through it we see, engrafted as it were, and superadded to the original nature, higher powers of agency, corresponding to our condition of mental superiority: these are not the organs of breathing merely, but of natural and articulate language also, and adapted to the expression of sentiment, in the workings of the countenance and of the breast, that is, by signs as well as by words. So that the breast becomes the organ of the passions, and bears the same relation to the developement of sentiments as the organs of the senses do to the ideas of sense.

OF THE NINTH PAIR; LINGUALIS, OR HYPO-GLOSSUS.

This nerve arises by a number of filaments coming off in regular succession from the medulla oblongata, and from the side of the corpus pyramidale, and betwixt that body and the corpus olivare. These filaments, collecting in the direction of the condyle of the occipital bone, pass out from the skull by the anterior condyloid foramen: when it has made its exit, this nerve adheres to the eighth pair, by cellular filaments*; and

* Some affirm that there is a connection by filaments of nerves at this junction of the 8th and 9th:—"etiam interdum tradita acceptave fibrilla nervea." Scarpa, Tab. 1.; so Asch. Fallopius.

from that part of the eighth nerve where it gives off the laryngeal branch, there comes off a communication to the ninth nerve. It receives also branches from the first cervical nerve, or from the branch of union of the first and second cervical nerves. Here it is also joined by a twig from the sympathetic nerve. When dissecting in the neck, we find the ninth nerve lying by the side of the internal jugular vein under the stylo-hyoideus muscle, and under the sub-maxillary gland, and near the horn of the os hyoides.

The nerve, making a curve to ascend again to the tongue, gives off that branch which is called the DESCENDENS NONI. The continued trunk of the nerve passes before the external carotid artery, and forwards under the larger branches of veins. It lies parallel to the lingual artery, but not so deep, and on a higher level. Here it turns upwards under the stylo-hyoideus and digastricus muscles, and betwixt the stylo-glossus and hyo-glossus. Where the nerve is near the os hyoides, and passing under the hyo-glossus muscle, it sends down a twig which passes to the thyreo-hyoideus muscle.

The continued nerve goes under the mylo-hyoideus, and is liberally distributed to the muscles of the tongue, but not before these branches have formed a sort of plexus. It terminates by numerous filaments, which form a net-work amongst the muscles of the tongue; to which is united part of that branch of the fifth pair which goes to the tongue.*

The RAMUS DESCENDENS NONI comes off from the lower edge of the ninth nerve, (the origin is covered by the internal jugular vein, and by the occipital artery.) This branch, near its origin, is connected with the par vagum; it then passes downward, obliquely over the sheath of the carotid artery, and under the thyroid vein. In the superficial dissection of the muscles of the neck, two slender twigs of nerves will be seen to come from the side of the neck, and, crossing the jugular vein, unite to this descending branch of the ninth. Those twigs come from the second and third cervical nerves, (in some instances those twigs are found to be derived from the first origin of the phrenic nerve); and a plexus is formed by their union with the descendens noni, viz. the superficial cervical plexus. From this centre are sent out many delicate and superficial nerves to the omo-hyoideus, sterno-thyroideus, and sterno-hyoideus muscles; and a branch of the descendens noni takes a course along the central tendon of the omo-hyoideus, to supply the lower division of this muscle. There is a branch of some interest, although small and deep, among so many greater nerves; it comes from the par vagum and the descending branch of the ninth, and joins this cervical plexus, where it may be traced piercing the scalenus muscle.

Thus we find that the ninth nerve has connections with the eighth pair of nerves, with the spinal accessory, the sympathetic, the cervical, and phrenic nerves. When this nerve is injured, the motion of the tongue is lost, but the sense of taste remains unimpaired. On the contrary, when the branch of the fifth nerve going to the tongue is hurt, the sense of taste is lost, while the mobility of the tongue remains.† Columbus knew a man who had no sense of taste, and who ate indiffer-

* This has been called *plexus cerato-basio-stylo-glossus!*
† Sœmmerring de Cerebro et Nervis.

ently every thing presented to him. When he died, Columbus was curious to know the cause of this, and he found that he altogether wanted the gustatory nerve or lingual branch of the inferior maxillary nerve. Cases detailed by Professor Scarpa still further illustrate this fact. A woman subject to epileptic attacks in an early age, was seized in her pregnancy with an hemiplegia and loss of speech. From this attack, by the use of medicines, she recovered; but in a future labour the disease recurred. Now the cure was less complete: for, though she regained the use of her arms, she never recovered the faculty of speech, or was only capable of articulating with great dissonance the monosyllables, affirming or denying. Upon making her exert herself to speak, they observed no motion in the tongue; and, upon applying the hand under the jaw, they could feel no motion in the muscles of the tongue; yet she relished her food and drink, and had an acute sense of taste, and could swallow easily. He mentions another case, where the patient was attacked with a sense of weight at the root of the tongue, a difficulty of speaking, and copious flow of saliva. In a short time he entirely lost the power of articulating, but retained acutely the sense of taste.*

OF THE CERVICAL NERVES.

We have done with the more irregular nerves of the head, and now we come to the spinal nerves, which all agree in structure and function, being double at their roots; and having one root given to bestow sensibility, and the other root to bestow motion.

First cervical nerve. Tenth pair of the skull. Sub-occipital nerve.—This is the least of all the nerves of the spine; it arises by two roots from the medulla spinalis. Some difference has been observed in the manner in which those roots collect their filaments; and only the anterior root or fasciculus is described by some authors. The posterior fasciculus is, indeed, the larger, and comes in a direction different from the general direction of the roots of the other cervical nerves. The roots of the sub-occipital nerve are connected with the spinal accessory nerve, so as to give rise to some difference of opinion, and sometimes they form a union with the posterior roots of the second cervical nerve. The fibres of the sub-occipital nerve passing transversely, and a little obliquely upwards, go out under the vertebral artery, and betwixt it and the first vertebra of the neck. The little trunk of the sub-occipital nerve, thus formed, forms its ganglion in the usual way, and, having escaped from the spine, rises for a little way upwards, and then divides into two branches.

The anterior of these branches is the smaller. It passes down upon the inside of the vertebral artery; its filaments unite with the hypoglossal nerve, or ninth pair, and with the superior cervical ganglion of the sympathetic, and with the first branch of the second cervical nerve.† The larger and posterior branch divides into eight twigs, which are

* Tabulæ Neurologicæ, Auctore Anton. Scarpa.

It has long been the author's intention to prosecute the subject of the nerves of the tongue, and he hopes in the succeeding season to accomplish it.

† A very small nerve is described by some authors as passing from the anterior division of this nerve into the canal of the vertebral artery.

chiefly distributed to the muscles moving the head—to the obliquus superior and inferior, the recti postici and laterales, complexus, and splenius. Some of those muscular branches unite with that branch of the second cervical nerve which ascends upon the occiput.

SECOND CERVICAL NERVE.—This nerve arises by a double origin from the spinal marrow, like the other nerves of the spine, and passes betwixt the first and second vertebræ. It is larger than the last, and divides into two branches.

The SUPERIOR BRANCH sends up a considerable division behind the projection of the transverse process of the first vertebra, to be united to the sub-occipital or first cervical nerve. Several twigs pass forward to unite with the superior cervical ganglion of the sympathetic nerve, and with some of the more anterior branches of the third cervical nerve, and with the ninth and spinal accessory nerves. Besides these intricate connections, irregular branches of this nerve proceed to the small muscles, moving the head, and lying on the fore part of the spine. The *posterior* branch of the second pair of cervical nerves is chiefly a muscular nerve. It rises up by the side of the complexus, gives branches to that muscle and to the splenius, and communicates with the branches of the first cervical. Its branches are also distributed to the upper part of the trapezius muscle, from which they extend along the integuments covering the occiput, even to the summit of the head.

The THIRD CERVICAL NERVE, in the first place, communicates with the second and fourth cervical nerves, then forwards with the sympathetic and lingual nerves. It sends down a twig to unite with the origin of the phrenic nerve from the fourth cervical nerve. From the anterior division of the third cervical nerve branches pass to the splenius and complexus and trapezius, and upwards to the ear. We may observe also a cutaneous nerve which accompanies the external jugular vein, viz. NERVUS SUPERFICIALIS COLLI; the distribution of which is chiefly to the angle and margin of the lower jaw, while some of its branches enter the parotid gland, and unite with the extremities of the portio dura and other facial nerves.*

The SMALL POSTERIOR DIVISION of the nerve passes to the complexus, spinalis cervicis, and multifidus spinæ, while at the same time it unites to the branches of the second cervical nerve.

The FOURTH CERVICAL NERVE, coming out from betwixt the third and fourth cervical vertebræ, divides into its anterior and posterior branches, like the other cervical nerves. The first goes to form, with the third and fifth cervical nerves, the PHRENIC NERVE. It sends also forward a branch to the sympathetic, and also to the integuments of the neck and shoulder, and to the supra and infra spinatus muscles. These are called by Sœmmerring SUPERCLAVICULARES ANTERIORES, MEDII, and POSTERIORES. And to these is attributed the false pains when the diaphragm is irritated. These, too, in all probability, cause the convulsions of the shoulder when the diaphragm is wounded.

The great POSTERIOR DIVISION of the fourth cervical nerve passes to the muscles of the spine and shoulder, in conjunction with the branches of the third cervical nerve.

* This nerve continues to give sensibility to the lower part of the face, after the branches of the fifth are cut.

FIFTH CERVICAL NERVE.—This nerve comes, of course, from betwixt the fourth and fifth vertebræ, and from betwixt the scaleni muscles. It divides also into two branches. The SUPERIOR of these passes backwards to the muscles of the back and shoulder; and a branch, formed by it and the sixth, passes down under the scapula and serratus major.

This last is the nerve I have described under the term EXTERNAL RESPIRATORY NERVE. It has the same source with the phrenic nerve; it is connected with that internal nerve; at its origin it is separated from the phrenic by a very small portion of the scalenus. Its course is through the axilla, passing deep under the nerves of the arm, and unconnected with the axillary plexus; it is distributed to the muscles on the side of the chest, and combines them into a class with the internal respiratory muscles. The superior division of the nerve sends up also two small twigs of communication with the fourth cervical nerve.

The INFEIOR DIVISION of the fifth cervical nerve sends down upon the side of the neck a considerable branch to the formation of the phrenic nerve. It communicates with the root of the sixth nerve, and sends muscular branches backward.

The SIXTH CERVICAL NERVE.—The muscular branches of this nerve are large, and extensive in their course. They pass into the levator scapulæ, extend under the trapezius, and unite with the extreme branches of the spinal accessory nerve. They are prolonged to the latissimus dorsi and serratus magnus. Branches also extend down behind the clavicle, and under the pectoral muscle.

Besides these branches, this nerve communicates with the fifth, and gives out an origin to the phrenic nerve; and lastly, uniting to the seventh, it passes into the axillary plexus.

The SEVENTH CERVICAL NERVE.—This nerve goes almost entirely to form the axillary plexus. There is a communicating nerve from the last of this, and from that communicating branch generally there passes off a filament to the phrenic nerve; and from the very root of the nerve there passes off a branch to the lower cervical ganglion of the sympathetic.* Irregular twigs also descend from this nerve under the clavicle to the pectoralis minor and major.

The EIGHTH CERVICAL NERVE.—The greater part of this nerve passes to the axillary plexus. It sends small branches to the lower cervical ganglion of the sympathetic, and to the muscles of the breast; which last descend behind the clavicle.

RECAPITULATION OF THE DISTRIBUTION OF THE CERVICAL NERVES.

Upon reviewing the description of these nerves, we find that the general tendency of their branches is backwards, over the side of the neck, to the muscles moving the head and shoulders. We find also that they are connected in a very intricate manner with the most important nerves of the cranium. High in the neck, and under the jaw, they are connected with the portio dura, with the fifth pair, with the eighth and ninth pairs, and with the sympathetic. Towards the middle of the

* These communications betwixt the cervical nerves and the sympathetic nerve are, I believe, branches of the sympathetic running down upon the arms.

neck they are still throwing their connecting branches to the descendens noni, and sympathetic, and eighth pair. The lower cervical nerves again are still supplying the connections with the lower ganglion of the sympathetic.

Further, we find that the phrenic nerve is derived principally from the third and fourth, and branch of communication betwixt the fourth and fifth. The inferior external respiratory nerve is derived principally from the fifth cervical nerve, and also has communicating branches with the fourth and sixth. The AXILLARY PLEXUS is formed by the fifth, sixth, seventh, and eighth cervical nerves, and first of the back.

OF THE DORSAL NERVES.

There are twelve dorsal nerves. These, like all the other spinal nerves, are formed by two fasciculi of fibres; one from the fore and the other from the back part of the spinal marrow. These filaments run for some way superficially in the length of the spinal marrow before they pierce the dura mater. They pierce it separately; the posterior root first forms a ganglion, and then the two fasciculi are united. They are now betwixt the heads of the ribs. We must here recollect, that the trunk of the sympathetic nerve, which passes along the thorax, runs down behind the pleura, and before the heads of the ribs through all the length of the back. It receives, as it passes the interstices of the several ribs, at each interval, a communicating nerve from the spinal marrow, that is, an additional root is afforded by each nerve as it passes; it is in a manner thus made up of roots from the intercostal nerves; hence the sympathetic is sometimes called *intercostal*.

The intercostal nerve, properly so called, sends its greater branch forwards betwixt the ribs; some lesser branches pierce backwards to the muscles of the back; opposite to this there goes out from each nerve the first branch of union with the sympathetic, and on this union a ganglion is formed. Sometimes there run out in this direction two short branches from the spinal nerve, to unite with the ganglion of the sympathetic; but more commonly there passes in a retrograde direction from the intercostal nerve, where it is about to take its course between the ribs, another branch of communication, which joins the sympathetic.

The intercostal nerves pass on betwixt the ribs, and under the protection of the groove on the lower edge of the rib, in company with the intercostal arteries, and reach even to the sternum. In this course they supply the intercostal muscles and triangularis sterni, while they are at the same time sending out branches, which, piercing the intercostal muscles and fascia of the thorax, are distributed to the muscles on the outside of the chest.—Those branches which we mentioned as passing betwixt the heads of the ribs, and which are sent off immediately upon the trunk escaping from the vertebral opening, supply the multifidus spinæ and levatores costarum, and other extensor muscles of the spine. Slips, proceeding from the second, third, fourth, and fifth intercostal nerves, send branches to the pectoral muscles, the serratus anticus, and serratus posticus superior, trapezius, and rhomboideus. The sixth, and all the lower nerves of the back, send branches from betwixt the ribs to the latissimus dorsi, serratus inferior, and abdominal muscles. The

eleventh and twelfth are distributed to the diaphragm, quadratus lumborum, psoas magnus, and iliacus internus.

LUMBAR NERVES.

The lumbar nerves are five in number. They arise like the other spinal nerves. The first comes out under the first lumbar vertebra, and the others in succession. Their trunks are covered by the psoas magnus. They pass very obliquely downward, and the three lowest are of remarkable size.

In the general distribution, we may first remark the posterior branches, which go backwards to the muscles which support and extend the spine. Again, the anterior branches; which give, 1st, additional branches to the sympathetic nerve as it passes over the vertebræ of the loins, and by which it is supported and reinforced till it terminates in the pelvis; 2dly, they have frequent connection with each other, and with the last nerve of the back, and first of the sacrum; 3dly, they send out branches, delicate but of great extent, to the muscles of the loins and back, and to the abdominal muscles and integuments of the groin and scrotum; 4thly, the principal anterior branches of the lumbar nerves pass down to form (along with the great nerves of the sacrum) the anterior crural nerve, the obturator, and the great ischiatic nerve.

SACRAL NERVES.

The nerves which come out from the extremity of the medulla spinalis, or cauda equina, through the sacrum, are in general five in number. Sometimes there is one more or less. The first division of each sacral nerve is into those branches which pass out by the posterior foramina of the sacrum, and those which, by the anterior foramina, come into the pelvis. The posterior branches are very small, and pass to the muscles supporting the spine; while the anterior ones are particularly large, especially the first and second, which, with the lowest of the loins, go to form the largest nerve of the body, the ischiatic nerve.

It is difficult to recollect the distribution of the several branches of the lumbar and sacral nerves, when taken thus together; but when we deliver the description of the nerves of the thigh and leg, we count them, and remember them with comparative ease. At present we are best prepared to follow the sympathetic nerve in its course.

OF THE GREAT SYMPATHETIC NERVE; OR, INTERCOSTAL NERVE.

The nerve called *sympathetic* is, in fact, an entire system of nerves, which distributed most evidently to the viscera of the thorax, abdomen, and pelvis, does in fact extend universally, by joining the other nerves of the head and extremities. But in this extended distribution it is lost by joining other nerves. While in the abdomen and thorax it is particularly distinct and demonstrable. The old method of describing the sympathetic nerve is to consider it as derived from the sixth and fifth, for they had no idea of a nerve but as a tube coming from the brain; for the sake of clearness we shall still describe it as thus descending.

The sympathetic nerve is in general considered as originally derived from the sixth pair; it also takes its origin from the first or ophthalmic division of the fifth pair, and from the Vidian branch of the fifth pair. It appears without the skull, sometimes behind and sometimes before the carotid artery; and sometimes it is double in its exit from the base of the skull. Almost immediately after it has escaped from the skull, it forms its first ganglion; which is very large and remarkable, and has the name of the SUPERIOR CERVICAL GANGLION of the sympathetic nerve. It is of a soft consistence and reddish colour, and it extends from the skull to the transverse process of the third vertebra. It gradually tapers downwards until it becomes a very slender nerve. This ganglion has much variety of shape in different subjects; and may be said in general to receive twigs of nerves upon the back part, whilst it gives them out upon the fore part.

The superior cervical ganglion of the sympathetic nerve receives nerves from the second, third, and fourth cervical nerves, and even sometimes from the root of the phrenic nerve. It has also connections with the hypo-glossal, par vagum, and glosso-pharyngeal nerves. It sends out branches to unite with the glosso-pharyngeal, and which follow that nerve in its distribution to the tongue and pharynx. Many of its branches surrounding the carotid artery form connections with the internal and external laryngeal nerves, and proceed in meshes or form plexus along with the branches of the artery. These may be followed to great minuteness.

To be more particular in the description of these anterior branches of the sympathetic nerve, they are called the NERVI MOLLES, or NERVI VASORUM. They are nerves peculiarly soft, with a greater proportion of cellular membrane; they spread in net-works along the arteries, and form frequent connections by little knots like small ganglions. Classed with these nervi vasorum are branches which pass forward from the upper ganglion of the sympathetic, to unite with filaments from the internal laryngeal nerve of the par vagum, and which form the external laryngeal nerve. It is remarked, that none of these branches of the sympathetic nerve are distributed to the larynx and pharynx without being mingled and associated with the glosso-pharyngeal nerve, or with the pharyngeal branch of the par vagum.* Of the nervi molles some form a plexus upon the internal carotid artery. These are extremely soft and pulpy, and are united with branches which descend from the glosso-pharyngeal nerve. A net-work is also formed, which covers the beginning of the external carotid artery. From this, as from a centre, branches are sent out with the arteries to the neck and face, and glands under the jaw; and these last, with a mesh which passes up upon the the temporal artery, unite with the portio dura of the seventh pair.

It has been often observed, that the branches of the carotid artery have a peculiar provision of nerves, and that these nerves are more numerous and minutely distributed than in any other part of the body. There are indeed no nerves in any part of the body which have so extensive and intricate connections with important vital nerves as the cutaneous nerves of the face and neck.

* Scarpa.

This distribution of the nerves has been considered a provision for that power possessed by the imagination, or rather that uncontrollable connection which exists betwixt the feelings and the action of the vessels in blushing, and in the expression of the passions. But I have proved this to be altogether false, since by cutting the portio dura of the seventh I have taken all expression from the face. The emotions visible in the countenance are, therefore, not attributable to the sympathetic nerve, and its nervi molles.

The lowest of the nervi vasorum or molles, sent off from the superior ganglion of the sympathetic nerve, descends in the course of the trunk of the nerve, and forms, with other branches, the superior cardiac nerve.

This nerve, generally called NERVUS CORDIS SUPERFICIALIS, passing down in the direction of the trunk of the sympathetic nerve, and near the longus colli muscle, is for some length a very slender branch; but in its course it receives two, three, or four additional twigs from the sympathetic, and branches which come under the carotid artery from the pharyngeal nerves. When this superior cardiac nerve is within an inch or two of the subclavian artery, branches of union pass betwixt it and the recurrent nerve of the par vagum; and branches of the nerves passing to the heart from the lower cervical ganglion also join it. It then, attaching itself to the investing membranes and sheaths of the carotid and subclavian arteries, forms with others a plexus of nerves, which run along the great vessels to the heart.

The continued trunk of the sympathetic, where it emerges from the superior cervical ganglion, is extremely small. It descends behind the carotid artery, and lies near to the spine.* When opposite to the fifth and sixth cervical vetebræ, the inferior cervical ganglion of the sympathetic is formed. In this course, twigs of communication pass betwixt it and the cervical nerves†, and join it with the beginning of the phrenic nerve.

But not unfrequently on the left side there are three cervical ganglions formed by the sympathetic nerve; the superior, middle, and inferior ganglions: or it happens that we find the sympathetic nerve split

* It is to be observed, that in the horse and the ass the sympathetic and the par vagum are incorporated in one sheath.

In the neck of the bird, the sympathetic is lodged within the canal for the vertebral artery.

† "Posterior nervorum spinalium radix, formato ganglio cui priore radice in unum "nervum colligitur, ut ad formandum nervum sympatheticum ambæ radices et posterior "et prior conferant — Nonnumquam re festinantius explorata, ramis ex priore radice "potissimum oriundis, constructus videtur; curatior autem disquisitio hanc opinionem "refellit." Sœmmerring, de Corp. Hum. Fab. vol. iv. p. 149.

According to Scarpa, the twigs which form the communications betwixt the ganglions of the sympathetic nerve and the nerves coming from the spine, join with these spinal nerves after the junction of their two roots. He has given a plate (tab. ii. fig. 1.) representing two of the communicating branches coming from the sympathetic nerve, and they fall into the spinal nerve just where the anterior root has become intimately united with the posterior root; so that it is impossible to say whether they have more connection with the one than with the other. "Vidi autem in quolibet nervo spinali "filæ quædam anticæ radicis, quædam posticæ, paulo infra ganglion a trunco spinali "abscedere, et versus ejus anteriorem faciem in unum ramum communi involucro "membranaceo vestitum convenire, qui intercostalem denique accedebat." Scarpa, Anatom. Annot. de Nerv. Gangl. et Plex. lib. i. cap. 1. § xi.

See some of the preparations in my collection.

into two branches in the neck; one of which forms the middle, and the other the lower ganglion.

There are received by the MIDDLE CERVICAL GANGLION, or THYROID GANGLION, branches of nerves from the third, fourth, fifth, and sixth cervical nerves, and also sometimes from the phrenic nerve. The ganglion is by no means constantly found, and it is irregular in its size and shape. When large, and in what may be considered as its more perfect state, it gives off some considerable branches. Of these, part unite with the superior cardiac nerve already mentioned; others form the great or deep cardiac nerve; while lesser ones play round the subclavian artery, and unite with the lower cervical ganglion, or the upper thoracic ganglion.

The deeper cardiac branch of the sympathetic splitting, and again uniting so as to form rings, runs outwards, attached to the arteria innominata and arch of the aorta, to the heart. In this course, while it passes before the trachea, it forms connections with the recurrent branch and trunk of the par vagum. Under the arch of the aorta we find this branch concentrated to form the GANGLION CARDIACUM of Wrisberg, or GANGLION MOLLE et PELLUCIDUM of Scarpa. This ganglion is like a mere enlargement or swelling of the nerve. From this, four or five branches may be enumerated; 1st, A branch passing behind the pulmonary artery to the back of the heart, and following the left coronary artery; 2dly, A small division to the anterior pulmonary plexus of the par vagum; 3dly, A pretty considerable branch which, passing behind the aorta, and betwixt it and the pulmonary artery, is distributed with the right coronary artery to the anterior part of the heart. On the left side of the neck, the sympathetic, receiving on the one side branches from the cervical nerves, and on the other giving off branches, which descend behind the carotid artery to the heart, (viz. the superior cardiac,) often splits before it forms the middle or thyroid ganglion, and sometimes throws its branches over the thyroid artery, and the ganglion lies upon that artery. Again, from the ganglion there descend two series of numerous lesser filaments, which form meshes upon the thyroid and subclavian arteries, to the heart. Others proceed downward behind the arteries to the lower cervical ganglion. Those branches which descend upon the arteries, intangle the roots of the thyroid, transversalis colli, and internal mammary arteries, in their plexus; these uniting, follow the subclavian artery, and form again a plexus upon the arch of the aorta. This is joined by branches from the par vagum and recurrent. The principal branches of this plexus terminate in the cardiac ganglion under the arch of the aorta.

The LOWER CERVICAL GANGLION of the sympathetic nerve is placed upon the limits betwixt the neck and thorax upon the head of the first rib, and by the side of the musculus longus colli; and it is in part covered by the root of the vertebral artery. The ganglion is of an irregular cushion-like shape. It lies close to the cervical nerves which go to the brachial plexus, and it receives branches from them. And even it receives branches sometimes from the fifth and sixth, more rarely the seventh and eighth, from the first and second of the back; and, lastly, from the phrenic nerve. Branches also pass from this ganglion to the par vagum and recurrent, and also pass on to the cardiac and pulmonic plexus. That nerve, which must be considered as the continued sym-

pathetic, throws a ring round the root of the vertebral artery, and, sending out branches upon the subclavian, terminates in the first dorsal or thoracic ganglion.*

THE SUPERIOR THORACIC GANGLION.

This ganglion surpasses the other thoracic ganglions in size. It is, indeed, frequently composed of many branches of the nerve in the neck, coming both before and behind the subclavian artery. It receives also nerves from the three or four lowest cervical nerves and first dorsal nerve. It is of a very irregular figure, or rather it varies exceedingly in its shape; so that by various anatomists it is described as round, oval, triangular, quadrangular, cylindrical! — Filaments proceed from this ganglion into the canal of the vertebral artery, which communicate with the sixth and seventh cervical nerves, and sometimes with the fourth, by a long descending filament.† This first dorsal ganglion communicates likewise with the first dorsal pair of nerves; and gives branches to the cellular coat of the subclavian artery, and to the cardiac plexus, and also to the pulmonic plexus; or to supply the posterior surface of the lungs.

SYMPATHETIC NERVE IN THE THORAX.

The sympathetic nerve (as we have explained in describing the dorsal nerves), through all its course in the thorax, has additional branches from the dorsal or intercostal nerves. It forms also, while it is lying on the side of the vertebræ, a division in the thorax, which it will be important to recollect. One nerve is sent more forwards upon the body of the vertebræ, and passes into the abdomen betwixt the crura of the diaphragm; while the trunk of the sympathetic continues its course by the heads of the ribs, passes over the ligamentum arcuatum, and downwards upon the lumbar vertebræ.

The SPLANCHNIC NERVE, then, is this anterior branch of the sympathetic in the thorax. It is the great nerve of the viscera of the abdomen. It generally has two or four roots from the trunk of the sympathetic nerve, where it is opposite to the sixth, seventh, and eighth intercostal nerves. It is seen lying under the pleura, and passing obliquely over the bodies of the dorsal vertebræ, from the seventh to the tenth. It then passes through the crura of the diaphragm, enters the abdomen, and forms the great semilunar ganglion.

One or more branches are sent forward from the sympathetic, commonly from the ganglions, opposite to the interstice betwixt the ninth and tenth, or tenth and eleventh ribs. These also pass the diaphragm, and unite with the semilunar ganglion. There is, however, a considerable variety to be observed both in the origins of the splanchnic nerve,

* The name applied to this part of the nervous system is manifestly erroneous, and tends so immediately to mislead the student that it should be entirely relinquished for that of *ganglionic nerve*, or *ganglionic system*; terms which refer to no theory of the functions performed by the structure. J. D. G.

† In brutes I have traced a considerable division of this nerve along the canal of the vertebral artery.

and in the number of these subsidiary branches. A larger branch, going off betwixt the tenth and eleventh ribs, is so common, that it has the name of SPLANCHNICUS MINOR, or ACCESSORIUS. This nerve as frequently terminates in the renal plexus as in the semilunar ganglion; or sometimes it sends branches to both.

SEMILUNAR GANGLION AND CŒLIAC PLEXUS.

The ganglion which is called the semilunar ganglion has no regular shape—and least of all when it is fully dissected. It is formed by the splanchnic nerve, and by branches which come from the lumbar nerves. It lies by the side of the cœliac artery, and consists of many lesser ganglions, (sometimes to the number of eleven or twelve,) matted together into a glandular-like shape.

The semilunar ganglions of the splanchnic nerves lie on each side of the root of the cœliac artery; their connection with each other is frequent and intricate; so that they throw a mesh of nerves round the root and branches of this artery, which is the great source of vessels to the stomach, liver, and spleen.—This plexus, formed by the semilunar ganglions round the cœliac artery, is the solar or cœliac plexus.

CŒLIAC PLEXUS.

The cœliac plexus is the great source of nerves to the higher viscera of the abdomen. The splanchnic nerves are the principal, not the only nerves which form this plexus. The par vagum sends branches down from the stomach which join it; and even the phrenic nerve, which is the nerve of the diaphragm, sends down twigs to unite to the branches of the splanchnic and par vagum. We shall find also small nerves which come from the seat of the kidney, and which are derived from the superior lumbar nerves.—These pass across the crura of the diaphragm, and enter into the cœliac plexus.—In pursuing the nerves of the viscera further, we have it no longer in our power to follow individual branches, but must rather mark the course, and enumerate the various sources, of the plexus and net-work of nerves which follow the great vessels.

From the cœliac plexus there pass out, 1. Nerves which accompany the phrenic arteries upon the lower surface of the diaphragm. 2. Nerves to the liver:—and of these there are two plexuses, the right and left hepatic plexus; one passes along the vena portæ, biliary ducts, and right hepatic artery, to the right side of the liver, the gall bladder and ducts; this of course is the RIGHT HEPATIC PLEXUS: the LEFT HEPATIC PLEXUS passes along the left hepatic-artery; and this has connection with the nerves of the stomach, branches of the par vagum. 3. That plexus, which runs upon the lesser curve of the stomach, while it is formed in a great measure by the par vagum, has also connection with the solar or cœliac plexus. 4. The plexus of nerves which pass to the lower orifice of the stomach and duodenum is chiefly a division of the right hepatic plexus. These nerves, to the liver, stomach, and duodenum, are attached to the branches of the cœliac artery. Along the great splenic artery, which is also derived from the cœliac artery, there passes out a plexus

of nerves to the spleen. From this splenic plexus there pass nerves to the great omentum; and they even unite with those passing out upon the duodenum, and which attach themselves to the right epiploic artery, and take a course upon the great curvature of the stomach.

Thus the solar or cœliac plexus is a great central net-work of nerves, which pass out in divisions to the liver, spleen, pancreas, stomach, duodenum, and omentum.

SUPERIOR MESENTERIC PLEXUS.

The place and connections of the superior mesenteric plexus is at once known, when it is considered that it is formed upon the root of the superior mesenteric artery.—It is formed by a division of the cœliac plexus, continued down upon the aorta so as to involve the root of the mesenteric artery, and by nerves coming over the side of the vertebræ of the loins from the lumbar nerves. This plexus spreads betwixt the membranes of the mesentery, and extends upon the branches of the artery, and is distributed to the small intestines and part of the colon. It consequently supplies the mesenteric glands, and it sends nerves also to the pancreas, that join those which it receives from the splenic plexus.

INFERIOR MESENTERIC PLEXUS.

The same mesh of nerves, being continued down upon the face of the aorta, surround the lower mesenteric artery, and follow its branches. This is the lower mesenteric plexus, or mesocolic plexus; and it is formed in a great measure from the branches of the continued trunk of the sympathetic nerve. As this plexus spreads upon the branches of the lower mesenteric artery, it passes to the left side of the colon, and rectum. While the lower mesenteric plexus is continued from the upper one, on the side of the lumbar vertebræ, it is continuous with the renal and spermatic plexus, and, towards the pelvis, with the hypogastric plexus.

Before considering the other lesser plexus of nerves in the abdomen, it is necessary to follow the continued trunk of the sympathetic nerve, which we had described as following closely the lateral part of the dorsal and lumbar vertebræ, whilst the splanchnic nerves pass obliquely over them to the viscera of the upper part of the belly.

The CONTINUED TRUNK of the SYMPATHETIC NERVE, after it has given off the splanchnic nerve in the thorax, sends several small nerves forward over the vertebræ to the mediastinum and sheath of the aorta. It then passes the diaphragm, keeping close to the transverse processes of the vertebræ. When, however, it comes lower upon the lumbar vertebræ, it lies more upon the side of their bodies; and the connections with the lumbar nerves are by small and numerous twigs which stretch over the side of the vertebræ. In this course, it is giving off upon the fore part numerous irregular twigs to the several plexuses which have been described. Where it lies under the vessels which pass to the kidney, it sends up some branches to the renal plexus.

The renal plexus, however, is not entirely formed of these branches of the continued sympathetic, but is rather a continuation from the cœ-

liac and superior mesenteric plexus; while the lesser splanchnic nerve, which was sent off in the thorax, also terminates in it. This plexus is thrown over the vessels of the kidney, and forms several little ganglions.

From the renal plexus descends the SPERMATIC PLEXUS with the vessels to the testicle. This plexus of nerves in woman follows the spermatic artery in its distribution to the ovaria and uterus.

In passing down upon the loins, the sympathetic nerve forms five or six ganglions with the branches from the lumbar nerves. These are oblong, angular, stellated,—irregular in their form, and in their number, situation, and size, as the twigs which, by their union with the sympathetic, form them. Betwixt these ganglions, or connections with the lumbar nerves, the sympathetic is not always one nerve, but is sometimes split into several smaller nerves, which unite again. From the sympathetic nerves of both sides we have to observe frequent interchange of branches, which sometimes attach themselves to the lumbar nerves, sometimes creep under the aorta, or unite to the plexus covering the face of the aorta.—There are several little ganglions formed by these nerves upon the face of the lumbar vertebræ: they have the name of GANGLIA ACCESSORIA.

Before the sympathetic nerve descends into the pelvis, it has become extremely delicate. In many subjects it seems to terminate in the last lumbar, or first sacral nerve; but, upon more minute dissection, lesser branches will be found to descend amongst the loose cellular substance of the pelvis. When regular, or perhaps we may say with truth when regularly and fully dissected, the sympathetic nerves of each side are seen to descend upon the fore part of the sacrum, and form connections with the sacral nerves similar to those with the dorsal nerves. As they descend, they of course approach, and finally unite in an acute point on the os coccygis. At the points of union of these extreme branches of the sympathetic nerves with the branches of the sacral nerves, small ganglions are formed; and there pass out branches from them, which cover the intermediate surface of the sacrum with an extensive plexus. The ultimate ganglion, formed by the union of the two sympathetic nerves, is the COCCYGEAL GANGLION, or, GANGLION SINE PARE, and from it there pass three or four nerves to the extremity of the rectum.

HYPOGASTRIC PLEXUS.

This is a plexus which lies on the side of the pelvis, and involves the hypogastric artery. It consists of the nerves passing to the parts contained in the pelvis; which do not, however, pass in distinct branches, but, like those of the abdomen, are formed into a minute interwoven network. The hypogastric plexus takes no determinate origin, but is continuous with, or formed by, the extreme branches of the sympathetic nerve, the extremity of the spermatic plexus, the sacral nerves, (and particularly the third sacral nerve,) and by the branches of the accessory ganglions on the sacrum.

FUNCTION OF THE SYMPATHETIC NERVE.

The opinion, borrowed from the continental writers, and more particularly from Bichat, has been entertained, that the sympathetic nerve of the human body was the same with the nervous cord found running down the centre of the *vermes*. This is paying too much respect to a name—too little attention to nature. Then, again, it has been said that this part of the nervous system should be called (with Bichat), the *ganglionic system!* True, there are ganglions universally distributed wherever we find the branches of the sympathetic nerve; but what a perversion it is when we know that the posterior root of every spinal nerve has a ganglion, to call this the ganglionic system, as if it alone had ganglions, and as if it were true that ganglions cut off sensation.

The nerves of the lower animals, though they in form resemble the sympathetic system, possess both power over the voluntary muscles, and bestow sensibility on the parts they are distributed to. We neither observe that the sympathetic nerve possesses voluntary power over the muscles, nor that it bestows sensibility. Surely this is enough to distinguish it from the system of the lower creatures.

The ganglions on the sympathetic nerve do not cut off sensation. There is no reason for continuing in that antiquated hypothesis, since I have shown that all the spinal roots which possess sensibility have ganglions.

In short, we only know what the sympathetic nerve is not; and by that means we are left to conjecture what really are its functions. It possesses no power over the features; it is not the nerve of emotion; it does not controul any voluntary motion: it has no sensibility. But, independent of these functions, we have to consider that the parts of the frame are united into a whole; it may be by the sympathetic nerve, which is universally distributed. The nutrition and growth of the body, —the circulation and secretion,—the desposition and absorption of the fluids and solids of the body require some controlling influence, and there is every probability that the sympathetic nerve performs these offices, ministering to the vital and constitutional powers.

NERVES OF THE ARM; AXILLARY, OR BRACHIAL PLEXUS.

The nerves which proceed from the spine, and go to supply the arm, are formed into an intricate plexus before they divide into the several nerves of the arm.

This brachial, or axillary plexus, is formed of five of the spinal nerves: viz. the fifth, sixth, seventh, and eighth cervical nerves*, and the first dorsal nerve. The highest of these nerves proceeds from betwixt the fourth and fifth cervical vertebræ; the last from betwixt the first and second dorsal vertebræ. They pass out betwixt the middle and anterior divisions of the scaleni muscles; and even while covered by this muscle, and before they have proceeded far from their foramina, the last nerve of the neck and first of the back unite.†—The plexus extends

* This is of course counting the sub-occipital as the first cervical nerve.

† Before the nerves which form the plexus intermix their filaments, or are connected together, they send off small branches to the scaleni muscles, to the muscles of the

from above the clavicle to the edge of the tendon of the latissimus dorsi. It allows of no natural division.* The axillary artery passes for some way close under it, and then perforates betwixt the divisions which form the radial nerve.

In the plexus of the axilla, the nerves of the arm make that interchange of branches which combines the muscles of the arm into classes, and which consequently orders the action of the muscles in the several motions of the arm and hand.

Before describing the plexus, I should notice the *nervi axillares intercostales*. These nerves do not belong to the axillary plexus. They come from the intercostal nerves, and, perforating the intercostal spaces, two or three nerves cross the axilla and go to the glands and integuments.—We may now arrange the nerves of the axillary plexus thus :—

1. The THORACIC NERVES.—Although the nerves which supply the muscles of the chest are derived from the intercostal nerves, as we have seen, yet there also pass off branches from the axillary plexus to the great and little pectoral muscles, to the latissimus dorsi, to the skin and mammæ. These thoracic branches proceed from the upper division of the plexus, or that which gives out the external cutaneous, and from one of the roots of the radial nerve.
2. The supra and infra-scapular nerves.
3. The circumflex, or articular nerve.
4. The perforans Casserii, or external cutaneous nerve.
5. The radial nerve (better named *median*).
6. The ulnar nerve.
7. The muscular spiral nerve.
8. The internal cutaneous nerve.
9. The nerve of Wrisberg.

Which may be arranged thus :—

I. Cutaneous nerves.	1. Nerve of Wrisberg. 2. Internal cutaneous nerve. 3. External cutaneous nerve, or perforans Casserii.
II. Nerves to the shoulder-joint.	1. Supra-scapular nerve. 2. Infra-scapular nerve. 3. Circumflex nerve.
III. To the muscles of the arm and to the fingers.	1. Radial nerve. 2. Ulnar nerve. 3. Muscular spiral nerve.

The SUPRA-SCAPULAR NERVE comes off from the upper edge of the plexus, and is the highest of the branches. It runs towards the root of the coracoid process, it passes through the notch of the scapula, and goes to supply the supra and infra spinatus muscles, the teres minor, and the sub-scapularis.

spine, and to the levator scapulæ.—The branches which they give to the sympathetic nerve we have already noticed.

* I mean that it admits of no division useful in the arrangement of the demonstration. See Monro's Nervous System, and the Latin work of Anton. Scarpa. Scarpa describes the connection of filaments betwixt the ulnar and radial nerves at their separation from the great plexus, *Plexus brachialis minor*. Vide tab. ii. fig. ii. h.

The SUB-SCAPULAR NERVES come out from the posterior part of the plexus along with the articular nerve. They are attached to the sub-scapular muscle; they turn round the fleshy edge of the muscle, and insinuate their branches betwixt the tendon of the latissimus dorsi and the teres major.

The CIRCUMFLEX, or ARTICULAR NERVE, or AXILLARIS, lies very deep. It comes from the back part of the plexus, passes behind the neck of the humerus, accompanied by the posterior circumflex artery, and above the tendon of the latissimus dorsi, and teres major. One of its branches we trace into the teres major; while another passes round the bone, and is distributed to the under surface of the deltoid muscle, the joint, and the cellular membrane.

The INTERNAL CUTANEOUS NERVE.—This nerve is derived from the ulnar at its root, or comes off from the plexus along with it; passes down the arm, giving off no considerable branches; accompanies the basilic vein, and twists its branches over it; divides into four branches upon the fascia of the fore-arm; and, running betwixt the fascia and veins of the fore-arm, it is finally distributed to the cellular membrane and integuments, while one of its branches reaches to the ligaments of the wrist.

The CUTANEOUS NERVE OF WRISBERG comes sometimes from the axillary plexus as a distinct nerve; sometimes it is a branch of the great internal cutaneous nerve; sometimes it is derived, or a nerve which takes its place is derived, from the intercostal nerves. This nerve of Wrisberg is distributed to the integuments of the arm, and terminates near the internal condyle.

PERFORANS CASSERII, or the EXTERNAL CUTANEOUS NERVE.—This nerve passes through the coraco-brachialis muscle before the os humeri, to gain the outside of the arm. From its perforating this muscle, and being described by Casserius, it is called the nervus perforans Casserii. Before passing through the coraco-brachialis muscle, it sends a nerve into the substance of that muscle. Here it also sends down a branch of communication with the radial nerve; and in many subjects it will be found to be like a branch from one of the origins of the radial nerve. Where the nervus perforans lies betwixt the brachialis internus muscle and biceps, (and, of course, after it has perforated the coraco-brachialis muscle,) a branch or two are sent up to the heads of the biceps muscle; another branch turns inward to the belly of that muscle; another is given to the brachialis internus; and, finally, twigs pass inwards to the cellular membrane which involves the brachial artery.

The continued nerve passes obliquely across the arm, and under the biceps. When approaching the outside of the arm, it divides into three small branches; one to the integuments which are upon the supinator longus, another to the integuments on the inside of the fore-arm, and a third, which continues its course along the edge of the supinator longus to the wrist. Of this prolonged branch of the perforans Casserii a minute twig is lost on the ligament of the wrist, another passes to the ball of the thumb, and a third goes round to the integuments of the back of the thumb.

The RADIAL OR MEDIAN NERVE.—This nerve is formed by those divisions of the plexus which surround the brachial artery, and sometimes

by a division from the perforans Casserii. It takes its course in the upper part of the arm by the outer side of the brachial artery. In the middle of the arm it crosses the artery superficially, and continues to lie on its ulnar side, separated from it by some thin cellular membrane, as far as to the bend of the arm. It gives off no branches until it has sunk under the aponeurotic expansion of the biceps muscle.

When the median nerve has come to the bend of the arm it gives off three branches. The first belongs to the pronator teres, flexor radialis, palmaris longus, and flexor digitorum; a second passes to the pronator teres; a third to the deep muscles of the fore-arm, to the flexors of the thumb particularly; and from this a fine branch attaches itself to the interosseous membrane, and, taking its course with the anterior interosseous artery, is distributed to the pronator quadratus muscle. The median nerve perforates the pronator teres, and then, continuing its course down the fore-arm betwixt the flexor sublimis and profundus digitorum, sends off branches to those muscles; and in this part of its course we see why the name *median* is more applicable than *radial*. Before passing under the ligament of the wrist, it gives out a branch which emerges from the tendons, and passes to the integuments, short flexor, and abductor muscles of the thumb.

The trunk of the median nerve passes with the tendons of the flexor muscles of the fingers under the ligament of the wrist. In the palm of the hand it divides into five branches: — the first passes to the abductor and flexor pollicis brevis; a second goes to the abductor pollicis, and side of the thumb next the fore-finger; the third passes to the fore-finger, and to the lumbricalis muscle; the fourth to the side of the fore and middle fingers; and the fifth to the sides of the middle and ring finger. All these nerves, while in the palm of the hand, send off branches to the lumbricales muscles.

The ULNAR NERVE comes off from the lower part of the plexus, in union with the internal cutaneous nerve. It descends upon the inside of the arm, accompanied by the inferior profunda artery, and is tied down by the firm intermuscular fascia, and then passes behind the internal condyle of the humerus. While above the bend of the arm, it gives off a superficial branch to the integuments on the inside of the arm, and the ulnar side of the fore-arm; at the same time it sends a muscular branch through the triceps muscle, along with the arteria profunda inferior. Immediately above the elbow-joint twigs are sent off, some of which accompany the ramus anastamoticus major of the brachial artery. After passing the condyle of the humerus, it sends a branch to the flexor carpi ulnaris, and to the head of the flexor digitorum profundus. It then sinks deeper betwixt the flexor ulnaris and flexor digitorum sublimis; it is here connected with the ulnar artery, and descends along with it to the wrist, lying on its ulnar side; when it approaches to the annular ligament, it is rather posterior to the artery. In this course, along the fore-arm, the ulnar nerve gives branches to the flexor digitorum sublimis. Often it sends a branch of communication to the median nerve, while some few lesser muscular nerves are sent off, and accompany the branches of the ulnar artery.

When arrived near the wrist, the ulnar nerve divides into two branches. The continued trunk passes on under the protection of the tendon

of the flexor ulnaris, and then under the annular ligament into the palm of the hand; while a branch, the ramus posticus, takes a turn under the flexor ulnaris, and over the edge of the flexor digitorum profundus; —it passes then over the lower end of the ulna to the back of the hand; on the back of the hand it is found branching over the expanded tendons and under the veins, and is finally distributed to the back of the little and ring fingers.

The continued ulnar nerve passes under the palmaris brevis muscle and palmar aponeurosis, and above the flexor brevis and adductor minimi digiti. Here it divides into two, viz. the sublimis and profundus of Camper. The superficial branch passes by the side of the abductor minimi digiti, to the integuments on the ulnar edge of the hand, and adductor minimi digiti,—to the outer edge of the little finger,—to the side of the little and ring fingers, and a branch communicates with the median nerve.

Albinus, Monro, and Camper differ in their description of the nerves to the lumbricales muscles, which only proves that the twigs passing to those little muscles are irregular. They come from the deep branch of the ulnar nerve. The deep branch (*profundus*) forms a deep palmar arch, and is sent to the lumbricales, to the adductor and flexor pollicis.

The MUSCULAR SPIRAL NERVE. — We find the external cutaneous nerve, or perforans Casserii, passing before the arm-bone. The muscular spiral nerve, on the contrary, passes behind the bone, and takes a spiral turn under it to get to the outside of the arm. It perforates the flesh of the arm betwixt the middle and the short head of the triceps muscle. Before it perforates the triceps muscle, the muscular spiral sends off branches which pass over the tendon of the latissimus dorsi; and before it enters the triceps muscle, it may be observed to divide into several branches. Three of these may be mentioned; a branch to the middle head, and one to the short head of the triceps muscle; and a third and larger nerve, which pierces betwixt the muscles, along with the trunk of the nerve.

This last nerve does not follow the trunk of the nerve in its course; but, perforating the triceps more directly across, it comes out behind the supinator longus, where it takes its origin from the os humeri. This is a cutaneous branch, and might be considered as the external cutaneous nerve with as much propriety as the perforans Casserii. Often we shall find some lesser branches of the muscular spiral nerve piercing the fibres of the triceps muscle, and terminating in the skin.

The great division of the nerve, after piercing the triceps muscle, lies betwixt the brachialis internus and the inner edge of the supinator longus; and here it sends a branch upon the bend of the arm, and on the edge of the triceps muscle. Where it is near the elbow-joint it divides into the *nervus profundus* and *superficialis:* the profundus gives branches to the extensor carpi radialis; then perforates the supinator radii brevis; twists round the radius; and here divides amongst the extensor muscles, sending branches to the extensor carpi ulnaris, to the extensor pollicis, and primis, secundus pollicis; the extended nerve, keeping still under the extensor tendons, passes to the back of the wrist, and is lost under the insertions of the extensores radiales.

But the great superficial division of the muscular spiral nerve comes

out betwixt the head of the supinator longus muscle and the joint. This branch then lies betwixt the supinator longus and pronator teres. Continuing its course by the side of the supinator longus and flexor radialis, on the outer side of the radial artery, it passes under the tendon of the former; it then becomes superficial, on the radial edge of the wrist; and is distributed to the integuments of the back of the hand, back of the thumb, fore, middle, and ring fingers. This branch is sometimes called *radial*.

NERVES OF THE THIGH, LEG, AND FOOT.

In tracing the nerves of the lower extremity, we find no difficulty in the arrangement, for they fall into a very simple and natural order. They are all derived from the lumbar and sacral nerves. They are three in number. 1. One passes out under Poupart's ligament to the extensor muscles of the leg, viz. those which lie on the fore part of the thigh. This of course is called the *anterior crural nerve*. 2. The second nerve is the *obturator nerve*, so called because it passes out from the pelvis by the obturator hole. This nerve passes out in the middle of the pelvis, lies amongst the deep muscles of the thigh, and distributes its branches chiefly to the adductor muscles. 3. The third nerve is the greatest nerve of the body. We may call it the *posterior crural nerve*; its proper name, however, is the *ischiatic nerve*. It passes out from the back part of the pelvis, through the sacro-sciatic notch, and takes its course down the back of the thigh into the ham. In this course it supplies the muscles lying on the back of the thigh, but its chief destination is to the leg and foot.

But before we attend to these three principal nerves of the lower extremity, we must notice the lesser nerves, which pass out from the pelvis, and which, indeed, are not without interest.

LESSER NERVES WHICH PASS OUT FROM THE PELVIS.

The cutaneous branches of nerves which have their source internal, are always important; because the internal affection, as in the present instance of the kidney, the intestine, the uterus, are attended with external pains, or pains felt as if they were external, and these will often guide us to the real source of the disease. There are three divisions of nerves which deserve attention for this reason; first, those cutaneous nerves which, coming off from the lumbar nerves, drop over the spine of the ilium upon the integuments of the hip and thigh. Secondly, there are nerves which course from the loins round in the spermatic passage, and go to the scrotum and membranes of the testicle, and, turning up from the groin, pass to the integuments of the pubes. In the third class are those nerves which go down upon the integuments of the thigh.

These cutaneous nerves of the thigh come from the lumbar nerves, or more immediately from the anterior crural nerve. They pierce the tendon of the oblique muscle of the abdomen, or pass under Poupart's ligament, and are distributed to the groin, scrotum, and betwixt the fascia and integuments of the fore part of the thigh. There may be described four cutaneous nerves on the fore part of the thigh, viz. the *external cutaneous*,

the *middle cutaneous*, the *anterior cutaneous*, the *internal cutaneous*, besides those of the groin and scrotum.

The EXTERNAL CUTANEOUS NERVE is that which comes out from the belly near the superior spinous process of the ilium. It is derived from the third lumbar nerve. It divides almost immediately into two great branches, and in the front view of the thigh the anterior branch alone is to be seen. It takes a course above the fascia in the direction of the line which divides the vastus externus from the rectus femoris, and terminates near the knee; while the posterior branch passes over the tensor vaginæ femoris, and down upon the outside and back of the thigh.

The MIDDLE CUTANEOUS NERVE is seen amongst the integuments of the groin, and emerges from under the fascia near the upper edge of the Sartorius muscle. It passes down upon the rectus muscle, and is distributed to the integuments in three or four divisions.

The ANTERIOR CUTANEOUS NERVE comes out to the integuments very high up, in the middle of the groin, betwixt the pubes and spine of the os ilii. It passes down the thigh along the surfaces of the Sartorius and vastus internus muscles. This, like all the other cutaneous nerves, runs above the fascia, and immediately under the skin.

The INTERNAL CUTANEOUS NERVE is the least regular. It does not pierce the fascia in one trunk, but sends three, four, or five branches through the fascia, which are distributed to the integuments on the inside of the thigh. Some of these, after running a considerable way under the fascia, emerge and encircle the inside of the knee.

We must not dismiss the consideration of those nerves without putting the knowledge of their distribution to some use. Suppose that a nerve of the spine divides into two, and that one branch goes internal to the viscera, and the other external to the integuments; it will come to pass that all internal morbid irritations will produce sensations attributable to the part to which the external or cutaneous nerve is distributed. These pains will not be easily described; and the terms the patient uses, too frequently, appear, therefore, fanciful.

Is this a sufficient explanation of the pain actually seated in the throat, affecting the back of the neck? The disorder actually seated in the heart, affecting the mammæ and arms? The disease of the lungs producing pain, referable to the back, betwixt the scapulæ? The inflammation of the liver, and the irritation of the diaphragm, pain in the shoulder? Disorders actually seated in the stomach, produce an extensive class of sympathetic pains. But the disorder of the duodenum is distinctly referable to the lower part of the back: as the distention of the colon, or the lodgment of matter there, produces pain in the loins and region of the kidney.

When we come to the contemplation of these nerves of the loins, the subject does not diminish in interest or usefulness.

1. Disordered function of the womb, conception, quickening, delivery, after-pains, menstruation, &c. produce pain in the lower part of the back and loins.

2. The disease of the testicle produces similar pain in the loins.

3. Disorder of the bladder often produces pains in the groin and perinæum.

4. Disorder in the rectum, or irritation of fæces there, produces pains in the perinæum, &c.

5. Lastly, diseases in the kidney and ureter produce pain down the fore part of the thigh, and retraction and pain in the testicle.

THE PUDIC NERVE.

The pudic nerve comes off from the third, fourth, and fifth of the sacrum, holding connection with the roots of the great ischiatic nerve. It runs towards the outlet of the pelvis, and to the side of the tuber ischii. In the female it sends branches to the anus, vulva, and clitoris. In the male it accompanies the common pudic artery in its course, and it consequently runs to the muscles of the anus, and of the perinæum, to the caput gallinaginis, to the penis, and to the glans, in many branches : and here it is the organ of a peculiar sense. Besides being the organ of venereal sensation, it bestows the sensation which orders the contraction of the bladder ; not only furnishing us with these sensations in addition to the common sensibilities, but, under the influence of these sensations, it controuls the various necessary actions of the muscles.

NERVES OF THE LOWER EXTREMITY.

ANTERIOR CRURAL NERVE.*

This nerve arises from the union of the second, third, and fourth of the lumbar nerves ; or, the second and third lumbar nerves, uniting into one trunk, are afterwards joined by a division of the fourth† ; or, the anterior crural is formed by the anterior branch of the third and the first branch of the second lumbar nerve‡, or by the four first lumbar nerves, and the first sacral nerve. At its origin, it lies under the psoas magnus, and, as it descends, it holds its course between the psoas magnus and iliacus internus. It then descends towards the thigh, and passes out under Poupart's ligament ; and, in its course along the brim of the pelvis, it is quite removed from the external iliac artery. Here, while within the pelvis, it gives off several small nerves, which pass into the iliacus internus, and to the psoas magnus muscles. These form a kind of small plexus.

As the anterior crural nerve passes under Poupart's ligament, it is imbedded between the iliac and psoas muscles, and lies about half an inch to the iliac side of the femoral artery. It here splits into its numerous branches which supply the muscles and integuments on the fore part of the thigh. From the fore part of the nerve there is sent out a musculo-cutaneous branch, which, while it descends and supplies several muscles of the thigh, gives out the middle cutaneous nerve. The anterior cutaneous nerve is sent off lower down. But almost immediately after it has passed under Poupart's ligament, the internal cutaneous nerve is sent off from some of those branches which run under the internal articular artery.

* *Crural nerve, truncus lumborum, femoralis magnus.*

† Fischer.—Walter. ‡ Sabbatier and Haller.

The last of the cutaneous branches of the anterior crural nerve, and the most important, is the NERVUS SAPHENUS, or CUTANEOUS LONGUS. This is the chief cutaneous nerve of the leg; but it is to be distinguished as a particular nerve, so high as under the external articular or circumflex artery, being a division of what is called the NERVUS LONGUS. This nerve is joined by a branch of the obturator nerve; and about the same place muscular branches are given off to the vastus internus.

When we are dissecting in the course of the femoral artery, we have to observe two nerves running parallel to and connected with the sheath of the artery. That which is on the inside is the largest, the course of which we shall prosecute. It follows the artery, lying along its outer side, and rather before it, as far as the tendon of the triceps muscle; it is here enclosed in a firm fascia, but it does not descend into the ham with the popliteal artery. It passes along the tendon with the perforating branches of the popliteal artery, or with the upper and internal articular artery. It then becomes a superficial nerve, having passed between the tendons of the gracilis and Sartorius muscles, and descends upon the inside of the leg with the saphena vein, to the inner ancle and foot.

This nerve, which lies near the femoral artery in the middle of the thigh, I have seen taken up with the extremity of the artery in amputation. This occasions twitching in the stump, and a good deal of distress.

Where the continued nerve descends upon the inside of the leg, it sends out many twigs to the integuments, and is entangled with the saphena vein. It has been pricked in bleeding in the ancle.—Sabbatier gives us an instance of this. The patient had been previously subject to nervous affections. She felt in the instant of the operation an acute pain, which was succeeded by convulsive motions, first of the limb, and then of the whole body. These attacks returned from time to time; she lost her health, and for many years was in great suffering. He relates to us another instance of the injury of this nerve accompanying the saphena vein, in the case of a young man who received a wound with the small sword in the inside of the knee. There came on much fever and swelling of the part, with great pain of the limb. This subsiding, there followed slight trembling of the limb, which gradually increased to an extreme degree. The caustic was proposed, but the patient had not resolution to let it be applied. After long suffering, with exhausted strength, he was at last relieved by nature, and his health gradually returned. When the nerve passes over the tibia, it is subject to be bruised, and I have seen tetanus proceed from such an injury.

These branches we have mentioned are only the cutaneous or superficial branches of the anterior crural nerve. The larger and more numerous set of branches are those to the muscles lying on the fore part of the thigh. These diverge suddenly in many twigs, and are entangled with the branches of the arteries, and follow them in their distribution. There can be no excuse for bestowing particular names on these branches;—to say that one is the branch to the pectinalis, another the branch to the Sartorius, another to the rectus, &c. is sufficient.

OBTURATOR NERVE.

This nerve arises, in common with the anterior crural, from the third and fourth lumbar nerves; or we say it arises by fasciculi from the second and third lumbar nerves, and sometimes by a small twig from the fourth. It lies under the internal border of the psoas magnus. It descends into the pelvis, and goes obliquely downwards to pass through the ligamentous membrane which fills up the thyroid hole. The obturator nerve, before it escapes from the pelvis, sends off a branch which, accompanying the parent nerve, is given to the external obturator muscle. When it has escaped from the pelvis, this nerve lies in the middle of the flesh of the thigh; here it divides into a deeper and more superficial branch; the more superficial lies betwixt the adductor longus and brevis, and divides into three branches. These divisions pass to the adductor longus, adductor brevis, and the gracilis. The branch which passes to the adductor longus sends a small nerve under the inner edge of that muscle, and down through the tendon of the triceps to the inside of the vastus internus, and there it unites with the nervus saphenus, and then passes betwixt the adductor longus and brevis. The posterior division of the obturator goes down betwixt the adductor magnus and brevis, sends branches to the obturator externus and adductor brevis, and continues its course downward before the great fleshy partition of the adductor muscles, and parallel with the crural vessels, to the fat above the inner condyle of the femur, and to the skin.

THE ORIGIN OF THE ISCHIATIC NERVE.

The ischiatic nerve is formed by the two last nerves of the loins, and the three first of the sacrum: or we may describe its origin more particularly thus; the anterior branch of the fourth lumbar nerve and the trunk of the fifth uniting, form a strong cord of about two inches in length: this root is joined to another nearly as large, formed by the first and second sacral nerves; and again, a third division joins it from the inferior branch of the second sacral nerve and from the third.* The ischiatic nerve is thus formed of three great roots matted together into a kind of plexus. It is flat, to escape from pressure; it passes backwards betwixt the pyriformis muscle and the gemini, and thus escapes from the back part of the pelvis by the great ischiatic notch.

But before following this great nerve into the thigh, we must take notice of some lesser nerves sent out from the sacral nerves, and from the trunk of the ischiatic nerve. These nerves pass to the muscles and integuments of the nates and back of the thigh, to the perinæum and private parts.

There pass off one or two very small nerves from the body of the ischiatic nerve, while yet within the pelvis, or from the middle divisions of its origins, which go to the pyriformis and glutæus medius muscles.

* This third and lowest origin, before uniting with the others to form the ischiatic nerve, gives out many small branches to the hypogastric plexus and viscera of the pelvis, to the perinæum and private parts.

Just where the great nerve passes over the posterior ligaments of the pelvis, there goes off a twig to the obturator externus, gemini, and quadratus femoris. While these branches are sent off upon the anterior face of the nerve, there goes backward a large fasciculus of nerves to the glutæi muscles, and to the integuments of the nates.*

When the integuments are dissected off from the nates and back of the thigh, we see two sources of the cutaneous nerves; first, from the lumbar nerves come many small nerves which pass over the spine of the os ilii; and, secondly, from under the lower margin of the great glutæus muscle, there come many extensive cutaneous nerves, of which that last described is the principal.

A little further down, the ischiatic nerve gives off small nerves to the muscles surrounding the hip-joint; and, whilst the sciatic nerve is passing over the quadratus femoris, the INFERIOR and INTERNAL CUTANEOUS NERVE is given off. This nerve runs down even to the inside of the calf of the leg.—The EXTERNAL and POSTERIOR CUTANEOUS NERVE is a branch sent off from the ischiatic nerve, after it has descended from under the glutæus maximus, and just before its division into two fasciculi, viz. the tibial and peronæal nerves. This external and posterior cutaneous nerve passes down upon the integuments of the back part and outside of the leg.

OF THE TRUNK OF THE ISCHIATIC NERVE IN THE THIGH.

But we must not allow these lesser branches to distract our attention from the general course of the great nerve, which passes over the gemini muscles, betwixt the tuberosity of the ischium and the trochanter major, then runs deep under the bellies of the hamstring muscles, and is lodged immediately in the great cavity behind the knee-joint, in company with the popliteal artery and vein. In this course the sacro-sciatic gives off branches to the quadratus femoris, the biceps cruris, semitendinosus, and semimembranosus and triceps.

A little below the middle of the thigh, the great ischiatic nerve divides into the internal and greater, and the lesser and external popliteal nerves. But as this is really the division into the two great nerves of the leg, they take the more determinate names of tibial and fibular nerves.

TIBIAL NERVE.

The greater and more internal of these divisions of the popliteal nerve is the tibial nerve. Whilst it is yet in the hollow behind the joint formed by the hamstring tendons, it gives off a nerve which comes out from the ham, and descends superficially on the back of the leg. This has been called RAMUS COMMUNICANS TIBIALIS. When this nerve has arrived opposite to the beginning of the tendo Achillis, it turns a little to the outer side, passing upon the outer margin of the Achilles tendon, over

* The *posterior cutaneous nerve* arises within the pelvis from the sacral nerves, and, connecting itself with the sciatic as it escapes, it afterwards descends upon the integuments on the back of the thigh; it sends branches also to the skin about the anus, and to the back part of the scrotum: pains are felt in the course of this nerve from disorder in the rectum.

the outer side of the heel-bone, and is finally distributed on the outside and fore part of the foot. Upon the back of the leg this nerve unites with a branch descending from the fibular nerve, nearly in the same course, and with the same destination.

After giving off this superficial branch, the tibial nerve sends branches to the back of the knee-joint and popliteus muscle, to the plantaris muscle, and to both heads of the gastrocnemius. It then descends behind the articulation, and behind the head of the tibia. It then passes under the origins of the solæus, and betwixt the solæus and flexor longus digitorum pedis, and tibialis posticus, and descends to the inner ankle, braced down by a very dense fascia. In this course it furnishes many branches to the lower part of the popliteal muscle, to the tibialis posticus, to the flexor communis digitorum, and to the flexor pollicis longus, and many of these branches end in cutaneous twigs. We have also to observe a particular branch which the tibial nerve detaches, which passes betwixt the heads of the tibia and fibula, and goes to supply the muscles arising from the fore part of the interosseous ligament. Further down, two or more small branches of the nerve also perforate the interosseous ligament, to supply the muscles lying on the outside of the tibia. The tibial nerve, in its course amongst those posterior muscles, accompanies the posterior tibial artery, lying on its outer or fibular side. When it has arrived behind the inner ankle, it sends off a branch to the integuments of the inside of the foot, and to the abductor muscle of the great toe. Continuing its course by the side of the heel-bone, and under the ligament, it begins to split into those branches which are naturally called the plantar nerves, because of their lying in the sole of the foot.

THE PLANTAR NERVES.

The internal plantar nerve passes over the abductur muscle of the great toe, and by the inside of the short flexor, to the first metacarpal bone ; and in this course it gives out several twigs to the muscles of the sole of the foot. It now divides into three branches. These are distributed to the great toe, to the second, the third, and one side of the fourth toes ; and these nerves in their course give branches to the lumbricales and interossei muscles.

The external plantar nerve is the lesser of the two. It gives branches to the short flexor and adductor of the little toe, and to the massa carnea Jacobi Silvii. It gives also a deep branch to the third and fourth interosseous muscle and adductor muscle of the toe. Another of its branches makes the arch with the internal plantar nerve, while its extreme distribution is to the little toe, and to one side of the fourth toe. These nerves of the sole of the foot are connected with the internal and external plantar arteries, and are protected like them by the plantar aponeurosis.

THE FIBULAR NERVE.

The fibular nerve is the more external division of the popliteal nerve. It separates from the tibial branch about four inches above the knee-joint ; it does not pass down under the gastrocnemius, like the tibial

nerve, but turns towards the outside of the joint, and passes round the head of the fibula, and under the origin of the peronæus longus.—Before the fibular nerve passes from behind the joint, it gives off several branches. There are sent down two branches to the integuments. One of these branches unites with the communicans tibialis, and descends with it to the outer ankle. Sometimes this anastomosis is formed high in the leg upon the heads of the gastrocnemius. More generally there is a double communication formed by these nerves, about the termination of the belly of the gastrocnemius muscle in the Achilles tendon. This prolonged branch of the fibular nerve terminates upon the side and upper part of the foot, and upon the little toe. There are also some nerves sent off from the fibular, which are distributed about the back and sides of the knee-joint.

When the fibular nerve has turned over the head of the fibula, it divides into two great branches. The DEEPER SEATED OF THESE BRANCHES, though it is not the largest of them, may be considered as the continued trunk. It passes deep amongst the muscles lying betwixt the tibia and fibula, and supplies the tibialis anticus, the extensor communis digitorum, extensor longus pollicis, and the peronæus brevis. Thus the deeper division of the fibular nerve, taking its course between the tibialis anticus, and the peronæus longus muscles, and lower down betwixt the tibialis and extensor pollicis longus, continues giving off branches in rapid succession, and when it arrives at the annular ligament it is much diminished. Here it divides into the *ramus dorsalis pedis profundus*, and *superficialis*.—This division is made after the nerve has crossed under the tendon of the tibialis anticus muscle, and while it lies betwixt the lower heads of the tibia and fibula.—Although they are distinguished by the name of deep and superficial branches, they are both deep compared with the extremities of the great and outer division of the peronæal nerve. The branch which lies most towards the outside of the foot passes under the extensor digitorum brevis muscle, and on the outside of the tarsus. It distributes its branches to the extensor digitorum brevis, and interossei muscles. That branch which is more towards the inside of the foot, although distinguished by the term superficialis, goes forward not only under the fascia which covers the foot, but also under the tendons; and after dividing and again uniting, and after sending off some small branches, it comes out betwixt the great toe and the second toe, and sends numerous branches to their contiguous surfaces.

The GREAT SUPERFICIAL DIVISION of the FIBULAR NERVE is sometimes double, or immediately splits into two. Its first branches are to the peronæus longus, extensor longus digitorum, and to the peronæus brevis and tertius. The trunk or principal division runs down under the head of the peronæus longus, and then, coming out from under it, continues its course beneath the strong aponeurosis which covers the muscles on the fore part of the leg. It then pierces the aponeurosis and becomes cutaneous, and runs obliquely down to the convexity of the foot, giving off in its course a nerve which passes over the outer ankle.

THE METATARSAL NERVES.

When the superficial branch of the peronæal nerve descends before the ankle joint, it divides into the metatarsal nerves, or the rami dorsales pedis. The EXTERNAL of those branches passes above the tendons, and above the tendinous expansion on the dorsum pedis ; is united to the extreme branches of the ramus communicans tibialis ; and is finally distributed to the outside of the third toe, to the fourth, and to the inside of the little toe.—The INTERNAL branch is again subdivided ; one branch extends over the middle of the foot to the second and third toes, while the other passes straight along the metatarsal bone of the great toe (above the tendons), sends many branches over the inside of the foot, and terminates on the inside and dorsum of the great toe.

The nerves of the lower extremity have the same connection with the visceral nerves, or the system of the sympathetic, that the nerves of the arm have, and this connection is further proved by various sympathies ; the influence of cold feet on the bowels, the effect of cold water dashed on the legs to promote a purgative, the spasms of the legs in cholera, pains in the knee preceding a fit of the bile.

OF THE

ORGANS OF THE SENSES.

OF THE SENSES.

INTRODUCTION.

THE brain is the seat of the mind; and certain mental changes are called perceptions. Those *changes* proceed, in the first place, from the operation of the organs of sense. The *organs of the senses* are so constituted as to admit the influence of things external to the body, while, through the connections of their nerves and the brain, they excite the mind to a condition corresponding with the external impressions.

It is in this manner, that through the organs of sense we receive those simple sensations which are the first elements of our thoughts, and the means of developing all the powers of the understanding. We never think of attending to the first simple intimations of the senses: before we are capable of reflecting on the nature of the perceptions which the several senses convey, they are so complicated and distorted by habits and association, that observation comes too late for us to ascertain the simple progress of nature.

To one who looks upon nature as a philosopher, there is a conviction that such researches may be carried too far. To whatever he directs his attention, to the changes of the globe itself, or to the structure of the human body, to the physiology of vegetables, or to the phenomena of chemical science: whether he endeavours to comprehend the great system of the universe, or pores over the minutiæ of natural science, he finds every where a limit placed to his enquiries; a line which no industry or ingenuity can enable him to pass. We may please ourselves with conjecture beyond this limit, but we find our opinions nothing better than a dream of something allied to the impressions of our gross senses. The agency of external matter on the senses, the influence of the organs of the senses on the mind, and the influence of the will over the body, are mysterious, and, probably, inexplicable phenomena; yet we scruple not to explain them precisely and mechanically; we reduce them to the level of our own capacity, in the same manner as mankind have formed the idea of a Divinity by the combination of all human perfections. Yet, when we imagine that we have discovered the secret of these mysteries, it is mortifying to find ourselves without any sign or language by which to communicate those great truths to the companions of our studies! We struggle for expression; and, as all our ideas upon such abstract subjects are derived from analogy, we express our opinions respecting the

powers of the mind, or the manner in which we perceive the objects of the senses, in the same language, and by reference to the same notions, which belong to the sensations themselves. From this scantiness and inaccuracy of language, it unavoidably happens, that very different ideas of the operation of the senses are expressed by several men in the same terms; and, in attempting to convey our ideas in language more precise and definite, we are insensibly led to materialise the faculties of the mind, and to make the operations of the senses merely mechanical. What other explanation can we give of theories, which suppose the nerves to be tubes carrying animal spirits, or containing an elastic ether; or which represent them as vibrating cords, and reduce all the variety of sensation to the difference of tension and tone? There are, indeed, what Dr. Reid calls them, "unhandy engines for carrying images."

Nothing has been undertaken in philosophy but entire systems, fathoming at once the greatest depths of nature. The custom has been to frame hardy conjectures, and if, upon comparing them with things, there appeared some agreement, however remote, to hold that as fully sufficient. What chimeras this method of philosophising has brought forth, it would be more invidious than difficult to specify.

The principles of philosophising have been laid down on this basis, that on no account are conjectures to be indulged concerning the powers and laws of Nature; but we are to make it our endeavour, with all diligence, to search out by experiment the true laws by which the constitution of things is regulated. In the subject now before us we have a very remarkable proof of the superiority of investigation by experiment over the lazy indulgence of conjecture; and I hope the whole tenour of the following account of the senses may serve, among other instances, to strengthen the conviction of the student, that it is only by assiduous study, and patient observation of nature, that he is to look for the attainment of knowledge in the medical profession.

The office of the brain and nerves is to receive the impressions of external bodies, by which corresponding changes and representations are made in the mind. We know nothing further than that, by the operation of the senses, new thoughts are excited in the mind. Betwixt the sensation excited in the organ of the external sense, and the idea excited in the brain, there is an indissoluble, though inexplicable, connection; the brain is not sensible, nor does the eye perceive, but both together give us the knowledge of outward things. But when the sensatian is once received and communicated to the brain, it is treasured there, and may afterwards be excited independent of the external organ: hence comes the term internal senses; for by the act of the will a retrograde impression may be made on the organs of the outward senses, they may be excited by imagination, which is an effort internal, as well as by an impulse from without. It is very agreeable to reflect, that the soul is no more bound to the things around us than is necessary to our present existence. It has powers independent of sensations; and the perceptions outlive the original cause of them in the influence of the organs of sense, and the material impulse which excites them. We are not creatures depending on external sensations merely; the impulse on our nerves is not the sole cause of our sensibilities: the conditions of the body itself furnish occasions of change to the mind; while many of its powers are possessed

and brought into activity independent of the material impulse on the organs of sense. Perception first arises from external impulse; memory is the power of recalling these perceptions, and imagination the power of combining them, and there ultimately arises a wide field for the internal affections, without dependence on the system of material things. These powers of the mind are weak in infancy, for then the perceptions are feeble and transitory; but by exercise and experience they acquire strength, the memory becomes vigorous, the store of ideas is increased, but still we are in a remarkable manner tied down to the ideas received from the external senses.

At the same time, I would not have it supposed that this connection betwixt the state of the mind and the external senses is a necessary dependence of the former on the latter. Wherever it is necessary to the safety of the individual, to the production of the species, to the formation of societies, to the relation of man with his Creator; faculties are bestowed, and perceptions and sentiments arise in the mind independent altogether of the operations of the external organs of sense.

When the mental powers are led to the contemplation of an idea which assimilates easily with the sensation about to be presented by the external organ, the perception is quick and vivid; but when the mind is strongly impressed and occupied with the contemplation of past ideas, the present operation of the sense is neglected and overlooked. Thus the vividness of the perception or idea is always proportionate to the degree of undistracted attention which the mind is able to bestow on the object of sensation or of memory. In solitude and darkness, the strength of the memory in the contemplation of past events is increased, because there is no intrusion of the objects of the outward senses; and the deaf or blind receive some compensation for their loss in the increased powers which are acquired by a more frequent and undisturbed use of the organs which remain, and a keener attention to the sensations which they present. On the other hand, when we are under the enchantments of a waking dream or reverie, our attention is wholly detached from the present objects of the senses. This state of absence, in a certain degree, is common and natural; it is the exercise of a faculty of the mind. But it may become disease; for the health of the mind consists in a balance of these powers, and a due correspondence betwixt the operation of the senses on the mind, and the efforts of the imagination independent of the senses.

The mind (united to the body) suffers in the diseases of the body. In the debility of the body, in fever, in spasms, and pain, the faculties of the mind languish, or are roused to unequal strength and to morbid acuteness of sensation. Sometimes the phantasms and internal sensations of things, formerly received by the outward senses, become so strong in the mind, as to be independent of the outward organ, and mistaken for objects actually present. Such frenzy or delirium arises from a disordered and acutely-sensible state of the internal senses. These impressions being great in degree, hurry and bustle is in the countenance of the patient, and uncommon strength and violence in his actions, just as passion gives great excitement to one in health, causing a disregard or forgetfulness of all besides. It is thus that internal perceptions become so strong as to be mistaken for realities, and attributed to

the impression of real existences. While in health, during the exercise of imagination, there is a conviction that the ideas are not realities, and the operation of the external senses preponderates in recalling the attention to what is around us.

Sleep is another state of the animal system, fitting it for its condition. It is a state of comparative repose and recovery. The child in the uterus sleeps always; the new-born infant sleeps a great deal; but, at length, the change of watchfulness and sleep appears to correspond with the revolution of our planet. Those, at least, will believe so, who perceive a correspondence in the weight of the body and the power of the muscles to the size and consequent attraction of the earth, and the condition of our fluids and circulation to the pressure of the atmosphere. During health, there are vicissitudes of consciousness and insensibility. This is true, however, only comparatively, and by a gross reference to degree; for even during natural sleep there is not a total oblivion of past perceptions, nor is there always a total unconsciousness of the present, as the senses are in part awake; some one train of ideas may be present to the mind, and the lapse of time may be observed. Even these perceptions are sometimes so strong as to be followed by voluntary exertion, and yet the person remains asleep.

Whatever conduces to take the excitement from the mind, or lessen the vivacity of its impressions, conduces to sleep. Thus, rest, stillness, and darkness, by excluding the most lively impressions conveyed by the senses; and hæmorrhage and evacuations, by lessening the velocity of the circulation; and cold, by lessening the sensibility, induce sleep. Again, compression of the returning blood from the head, by giving it a slow languid motion, and by depriving the vessels of their freedom of action, also conduces to sleep; because, as formerly remarked, the powers and faculties of the brain must be renovated through the means of the circulation: and by the diminished circulation there is a diminished sensibility, and therefore a weakness of impression on the external senses: all these consequences of impeded or diminished circulation, and consequent debility of the powers of the mind, should be distinguished from natural repose of the mind in sleep, a condition obviously imposed upon us, as I have said, in reference to the circumstances in which we are placed.

By long watching and fatigue, the body is brought nearly to a feverish condition. By sleep, rest is given to the voluntary muscles, and an abatement of the vital motions ensues; the quiescent state of the muscles permits the blood to return to the heart, with a slow, regular, and calm progress; the heart is restored to its equable pulsation; the breathing becomes more gentle, and the wasted strength of the system is recruited. We may define sleep to be a state in which the sensations are dull, the voluntary muscles at rest, and the vital motions calm and regular.

In dreaming, the sensations are dull and obscure, but the imagination active.

In the soporific diseases the vital actions, which are calm and slow during natural sleep, become oppressed; and the sensibility (which is gradually diminished upon the approach of sleep, but always capable of being roused by the senses,) becomes quite oppressed; the voluntary

muscles are relaxed, as in natural sleep, but sometimes convulsed by irregular motions.

In apoplexy, the faculties of the mind, and those powers of the nervous system which are placed under the guidance of the will, are suspended, while the vital operations proceed; and life continues until the derangement reaches the vital organs, which sooner or later happens, for the body is a whole, and part of it cannot exist separately in a state of activity.

Somewhat opposed to the state of apoplexy is that condition where the imagination is oppressed by some sensation, as in the night-mare, while the powers of motion are locked up.

If natural sleep is not profound, the imagination is awake; but there may be false perceptions, false judgment and associations, and disproportioned emotions; and when sensations are perceived, they do not produce the ordinary associations. If such a state of the intellectual functions occurs during the waking state, it becomes delirium. That this delirium is analogous to the perturbed state of the imagination during sleep, appears from the delirium in fevers uniformly showing its approach in the patient's slumbers. It is a disposition to form false images and associations, which, in the beginning, the excitement of the outward senses has power to counteract, insomuch that a patient can be roused from delirium as he can be roused from sleep; but, by-and-by, the external senses lose their superiority, and their excitement is attended with unusual associations; they no longer convey impressions to the intellect, but become subservient to and modified by it, and the judgment, which depends on the due balance of memory and imagination, is lost. In fever, the delirium is transitory; in low fevers, it is combined with a comatose state; in melancholy, the delirium runs upon one object chiefly, or one train of ideas, which refer to the patient's health and corporeal feelings; in madness the variety is infinite, but chiefly consisting in a vitiated imagination and perverted judgment, with fierceness and increased power of corporeal exertion.

There are five organs peculiarly adapted to convey sensations to the mind; or, as I am more inclined to say, to rouse the faculties of the mind by exercising the internal organs of the senses in the brain: these may be considered as forming a medium of communication betwixt the external creation and the sentient principle within us; and in some measure the bond of union betwixt sentient beings. These organs are called the EXTERNAL SENSES; viz. the sense of seeing, the sense of hearing, the sense of smelling, the sense of tasting, and the sense of touch. If I were willing to break in upon received opinions in an elementary book, I would say that there is a sixth sense, the most important of all, the sense of motion; for it is by a sense of motion that we know many of the qualities of outward things, as their distance, shape, resistance, and weight. Individually, these organs convey little information to the mind; but by sensations received through them, by comparison, by combination or association, minister to the powers of the understanding, to memory and imagination, to taste, to reason and moral perception, to the passions and affections, and, in short, to the active powers of the mind.

OF THE ORGANS OF THE SENSES.

Let us not deceive ourselves into the belief, that by attention to this subject we shall be enabled to comprehend the nature of sensation, although the impression be made directly on the nerves of touch, taste, and smelling. We, perhaps, understand something of the body impressed; and we see the naked nerve on which the impression is made, and yet the effect is incomprehensible. In truth, when engaged in the study of the senses, we learn only how the strength of impression is increased, *e. g.* how the eye is calculated to transmit, and to accumulate, and to strengthen the impression on the nerve; or how the organization of the ear increases the vibrations of sound; but of the nature of sensation we learn nothing.

OF THE EYE.

INTRODUCTORY VIEW OF THE PRINCIPLES OF OPTICS.

The organ of vision is a subject of general interest, every man of education studies it. That my reader may have a proper interest in it, we shall begin the investigation by an enquiry into the properties of light.

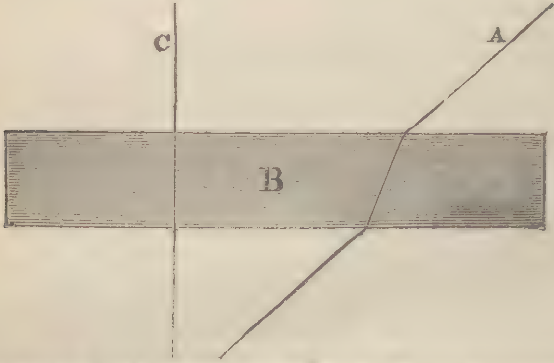
The grand source of light is the sun; but we may say, that light is a matter thrown out from ignited, or reflected from shining surfaces; which, entering the eye, and impressed on the nerve of that organ, gives the sensation of sight. The minuteness and inconceivable velocity of light, the facility with which it penetrates bodies of the greatest density and closest texture, without a change of its original properties, make it the source of the most wonderful phenomena in the physical world.*

The smallest stream of light which propagates itself through a minute hole, we may call a ray; and, as rays of light pass through a uniform medium in a straight course, they are represented in our diagrams by lines. But a ray is not simple; light is not uniform in respect of colour; every part of a ray is not capable of exciting the same idea when impelled on the nerve of the eye. White light is composed of different kinds of rays, which individually give a different sensation: one of red, another of orange, a third of yellow, a fourth of green, a fifth of light blue, a sixth of indigo, and a seventh of a violet or purple. These are

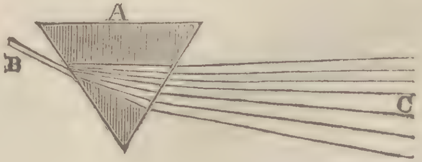
* This is the Newtonian doctrine; but there are great names, as Hooke, Huygens, Euler, and Dr. Young, who support an opinion, that light results from the undulations of an ethereal medium pervading matter. On the truth of this I cannot decide, but the opinions of Newton form the more simple introduction to optics and to the structure of the eye. As to making the impression on the eye analogous to the impression on the ear, I would be inclined to turn the argument the other way, and say, that the senses are each of them endowed with a property of receiving distinct impressions from the qualities of matter which are dissimilar.

named the prismatic colours; because, in the spectrum produced by making a ray of light to pass through a prism, these several colours are seen in the succession in which they are above enumerated. Each of these rays individually impresses the eye with its own colour; but, when they all impress the eye at once, the sensation upon the organ of sight is a compound effect; no individual colour is presented, but that mixed light which is called whiteness. Dr. Wollaston limits the prismatic colours to four — four primary divisions of the prismatic spectrum. These colours are *red*, *yellowish-green*, *blue*, and *violet*.

It is the nature of most bodies to attract these rays of light differently, and consequently to produce different colours. A body absorbs some of these rays of light, and reflects others from its surface; the colours of bodies depend upon the particular rays which are reflected from them, or upon the combination of such rays as are reflected from them; and therefore they appear of that colour of which the light coming from them is chiefly composed.



When a ray of light passes from a rarer to a denser medium, or from a denser into a rarer (as A into B), it alters its course, if there be any obliquity in the original direction; but if it strikes from one medium into another perpendicularly to the surfaces (as C), its original direction is not changed. If the ray passing from the air enter obliquely into glass or water, or any denser medium, it turns more towards the perpendicular; but if it pass through the glass, and emerges again into the air, it resumes its original direction, diverging from the perpendicular. This effect of different mediums upon the ray of light is called refraction: when a ray of light impinging upon a surface does not enter, it rises again at an angle equal to the angle of its incidence; and this is reflection.



The prism is a piece of glass of a triangular form, of which we have here a section at A; the inclined surfaces of which, when placed in the course of the ray of light B, refract, and separate the several parts of the heterogeneous ray, and show its compound nature, C. If the sun be permitted to shine into a dark room through a small hole in the window-shutter, and the beam of light be made to fall upon a glass prism, it is, in passing through the glass, separated into its constituent parts; because the several coloured rays have different degrees of refrangibility, in the order in which I have already enumerated them. If the rays, after passing through the prism, be made to pass also through a convex glass, they are brought again to a point in the focus of that glass; and the effect of the whole colours, thus re-united, is perfect whiteness. We might suspect that the beams of light were homogeneous, and that the degree of refraction gave different colours to the rays, were it not proved, that how much soever any of the coloured rays is further refracted, it does not change its nature; nor will rays suffer any change by reflection from bodies of different colours, for red lead will appear yellow, green, blue, &c. according to the colour of the ray of light directed upon it. It is found, that the coloured rays have not all the same power of illuminating objects: the orange ray possesses this property more than the red: the yellow more than the orange, &c.; and the maximum of illumination lies in the brightest yellow or palest green; nor do the several rays equally affect the thermometer.*

As the impression of light remains some time upon the nerve of the eye, it gave Sir Isaac Newton the opportunity of examining whether each coloured ray makes a distinct impression on the eye, or whether they so affect each other as to impress the sense of whiteness on the eye. When a burning coal is whirled in a circle, the eye perceives an entire circle of fire, because the impression made by the coal in any point of the circle remains until the coal returns again to the same place, and renews the sensation. When all the varieties of colours are painted in a circle, and turned in the same way with the burning coal, they must each make their separate impression upon the optic nerve; but the general sensation is whiteness; or, when the teeth of a comb are drawn across the stream of light issuing from a prism, the different colours are intercepted in such quick succession, that a perfect whiteness is the result of the mixture of impressions. There are many experiments which show that the inequalities of the refraction of light are not casual; that they do not depend upon any irregularity of the glass: on the contrary, it is proved that every ray of the sun has its own peculiar degree of refrangibility, according to which it is more or less refracted in passing through pellucid substances, and that the rays

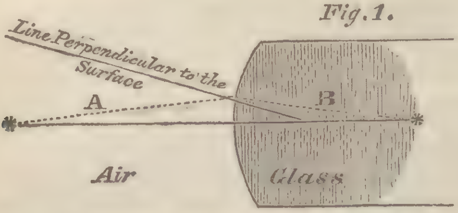
* This curious fact we owe to Herschell. He found not only that the prismatic rays had different powers, both of heating and illuminating objects, but that there were invisible rays beyond the red margin of the spectrum, which had no power of illumination, but only a power of heating. Other rays, invisible, but possessed of a chemical influence, have since been discovered, beyond the violet extremity of the prismatic spectrum.

Light moves with inconceivable velocity; 195,000 miles in a second. How minute, then, must it be, to make no impression but on the appropriate nerve of the sense. See Herschell's Exp. Phil. Trans. 1800, p. ii. p. 255.

are not split and multiplied by the prism ; but that rays originally constituted distinct, are separated by this instrument.

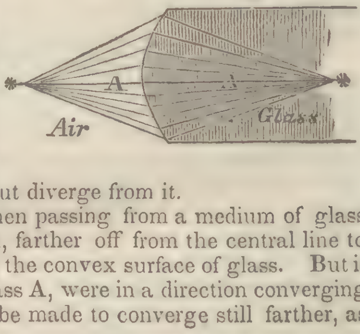
When a ray of light falls upon the surface of glass obliquely, it inclines to a line drawn (through the point of incidence) perpendicular to the surface.

Fig. 1.



Thus the ray A, proceeding from the object, is refracted upon entering the mass of glass in the direction of the line B, having a tendency towards the perpendicular line. By this means, if a number of rays, proceeding from any one point, fall on a convex or spherical surface of glass, they will be inflected so as to gather about the perpendicular line AA, in the centre of the glass ; which perpendicular line is the axis of the glass. If the rays of light proceeding from an object be made to strike into a mass of glass with a concave surface, the obliquity with which they impinge upon the surface, being the reverse of the convex surface, they are not made to converge upon the central line, but diverge from it.

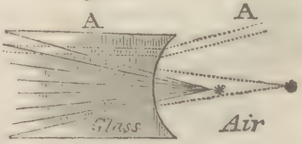
Fig. 2.



Farther, the rays of the sun, when passing from a medium of glass into the air, are turned, by refraction, farther off from the central line to which they were drawn in entering the convex surface of glass. But if the rays, in passing through the glass A, were in a direction converging to the perpendicular line, they will be made to converge still farther, as is seen here in the figure.

Fig. 3.

Fig. 4.



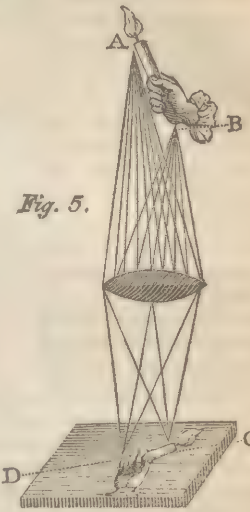
If, however, the rays be made to pass from the glass B, into the air, and the surface of the glass be concave, the rays will be made to have a less degree of convergence, so as to remove the image * farther from

the surface of the glass. But if the rays passing through the medium of glass have no convergence, but pass in parallel lines, they will diverge as the lines A A do, when they emerge from the concave surface of the glass.

We see, then, the operation of a double convex glass, in forming the image of a luminous body upon a surface. If, for example, such a glass be held between a candle and a piece of white paper (the distances being properly adjusted), the image of the candle will appear very distinctly upon the opposed surface, but inverted; because the rays coming from the point A converge at C, and those from the point B at D.

Before proceeding farther in this short exposition of the principles of optics, it will be necessary to take a very slight view of the structure of the eye, and let us apply these facts in explanation of its structure.

Fig. 5.



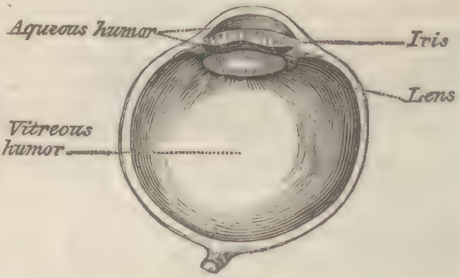
INTRODUCTORY VIEW OF THE STRUCTURE OF THE EYE.

The function of the eye is not simply to transmit the rays of light to the expanded optic nerve: it collects the rays and presents them in a small compass, the impression being stronger or more intense from the concentration of the rays. It is the first principle of the constitution of the eye, that the rays of light must be so concentrated as to impinge strongly on the expanded nerve or retina in the bottom of the eye. Now, as we have seen that a lens (which is a double convex glass) is necessary to concentrate the rays of light proceeding from an object, so as to form a small and lively image of it (as in the marginal plate), in the same manner an essential part of the eye is the lens, which brings the rays of light to a focus; and that the lens may make the rays proceeding from an object converge into an accurate focus, so as to form a distinct image on the eye, the vitreous humour is interposed betwixt the lens and the surface of the retina. Again, it is necessary to the constitution of the eye, that, in order to increase the sphere of vision, the anterior part of it shall project and form a large segment of a small circle, so as to take a greater circumference into the sphere of vision than could have been done, had the larger sphere of the eye-ball been continued on the fore part. Another necessary part of the apparatus of the eye is the iris, which is a curtain in the anterior chamber of the eye, perforated with a hole, which is capable of being enlarged or diminished, so as to admit a larger or smaller stream of light according to the intensity of the light.

In this provision we see the necessity of the anterior humour of the eye being different from the others. It is a perfect fluid, a mere aqueous secretion, while the others possess a degree of firmness: thus the iris or curtain of the eye is permitted to move with perfect freedom in it.

The humours of the eye, therefore, are three; the aqueous, crystalline, and vitreous humours; and they stand in this relation:—

Fig. 6.



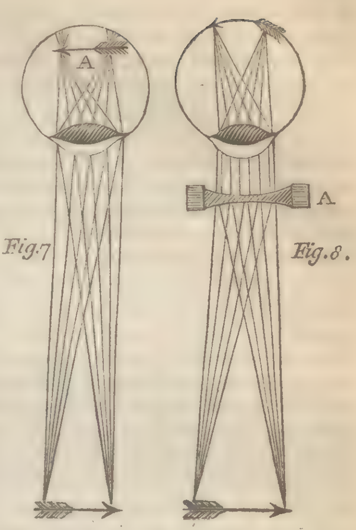
1. The AQUEOUS HUMOUR is the anterior humour of the eye. It distends the anterior and pellucid part of the eye, so as to increase the sphere of vision. It is perfectly fluid and of a watery consistence, that it may allow free motion to the iris.

2. The LENS OR CRYSTALLINE HUMOUR is placed immediately behind the perforation in the iris; which perforation is called the pupil. The lens collects the rays of light like a double convex glass, so as to concentrate them, and make a more forcible image on the bottom of the eye.

3. The VITREOUS HUMOUR is behind the lens. It distends the great ball of the eye into a regular sphere, that it may move easily in the orbit; and its diameter in the axis of the eye is so proportioned to the focal distance of the lens (affected also in some degree by the other humours), that the image of an object is formed accurately on the surface of the retina; accordingly, when the coats are cut from the back of the eye, the picture of a luminous object held before the pupil is seen exquisitely minute and distinct on the bottom of the eye.

While these humours have each its distinct character, they possess, in proportion to their density, different powers of refracting the rays of light. This has the still farther happy effect of correcting the dispersive powers of the humours, and giving the truest colours, as well as the most correct image of the object presented to the eye. It was not till the present day that the method was invented of correcting the false colours which form around the image of an object seen through powerful magnifying glasses; at last, Dolan invented the achromatic telescope, by compounding the lenses of two different kinds of glass. It is almost superfluous to add, that the eye possesses this power, and in it the true colours only of an object are represented on the nerve of the eye. (See *Of the Lens.*)

If the lucid anterior part of the eye be formed too prominent, or if the lens of the eye have too great a degree of convexity, or, lastly, if the size of the ball of the eye, and consequently the diameter of the vitreous humour in the axis of the eye, be unusually great, then the person does not see distinctly; because the powers of the humours, in concentrating the rays of light, are too great, and the image of the object is not formed accurately on the retina, but before it. Thus the convexity of the cornea, the lucid anterior part of the eye, or the focal



powers of the lens, being too great for the distance intervening betwixt the lens and retina, the image is formed at A before the rays reach the surface of the retina; and, after coming accurately to the point, they again begin to diverge; which diverging rays, striking the surface of the retina, give the indistinct vision of a near-sighted person. But as this indistinctness of vision proceeds from no opacity, but only the disproportion of the convexity of the eye to the diameter, the defect is corrected by the concave glass A; for, the effect of this glass being the reverse of the convex lens, it causes the rays to fall correctly upon the surface of the retina; that is, it corrects the too great convergence caused by the convexity of the humours. But, when a near-sighted person has brought the object near enough to the eye to see it distinctly, he sees more minutely, and, consequently, more clearly; because he sees the object larger, just as a person does when assisted with a magnifying glass or lens.

The near-sighted person sees distant objects indistinctly; and as the eye, in consequence, rests with less accuracy upon the surrounding objects, the steady piercing look of the eye is diminished. Again, the near-sighted person knits his eyebrows, and half closes his eyelids: this he does to change the direction of the rays, and to correct the inaccuracy of the image, in a manner which may be understood by the following analogy. If we make a card approach a stream of light passing through the window, it will so attract the rays of light, as to extend the margin of the figure of the circular spot of light upon the wall. In the same way, when a stream of light, proceeding from an object towards the eye, is made to pass through a small hole, the circular margin of the hole so attracts the rays, as to produce an effect similar to the concave glass, or as if they proceeded from a nearer object; the image is carried farther back from the lens. When a near-sighted person peers through his eyelids, the margin of the eyelids or the eyelashes attract and disperse the rays in a certain degree. This corrects the imperfection of the humours, and the rays impinge more accurately upon the retina, and he sees more distinctly.

The effect of old age is gradually to reduce the eye to a less prominent state, and, consequently, to bring it to the reverse condition of the near-sighted eye; near-sightedness, therefore, diminishes with old age.

From the decrease of the humours, and the lessened convexity of the cornea, the image of objects is not formed soon enough to impinge accurately on the retina, the rays tend to form the image behind the retina,

or they meet the retina before they have arrived at what is termed their focus.

In this figure, we have the effect of old age on the humours represented: without the intervention of the glass A, the rays have a direction which would form the image at some distance beyond the retina, as at B. But by the convex glass A (which is of the nature of the common spectacles for old people) the direction of the rays of light is so corrected, that the image falls accurately on the bottom of the eye.

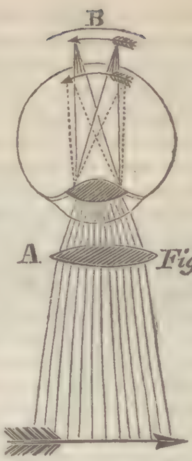


Fig.9.

We understand, then, whence these opposite defects of sight arise; that, in old people, objects cannot be seen distinctly when near, and, in short-sighted people, they cannot be seen distinctly when at a distance. We see, also, why old age corrects short-sightedness by gradually reducing the convexity of the eye, enabling the person to see objects farther removed, until, by degrees, he comes to see perfectly at the distance most convenient for the common affairs of life.

It has been, by some, thought extremely difficult to account for the image appearing to us, as it is in reality, erect, since it is actually figured on the bottom of the eye in an inverted position; but the terms above and below have no relation to the image in the bottom of the eye, but to the position of our bodies and the surrounding things. When I look to a tall man's face, I direct my eyes upwards; I observe his situation, as it relates to the area before my eye, or to a space in the sphere of vision. I know, after long experience, that I direct my eye; and it is the effort of direction, combined with the sensation of the retina, that gives the compound idea of the place of the object. Motion of the eye (if not produced by the voluntary effort of the proper muscles of the eye), conveys no idea; the image does not appear to move.

When an object approaches towards the eye, the diameter of the picture on the retina increases in the same proportion as the distance between the eye and the object decreases; and, consequently, it decreases in the same proportion as the distance increases. But the degree of brightness of the picture of an object on the retina continues the same at all distances, between the eye and the object, unless some of the rays of light are interrupted in their progress; for, as the advancing object becomes bright, it increases doubly in length and breadth, or quadruply in surface. The faint appearance of remote objects is occasioned by the imperfect transparency of the atmosphere.

There is nothing more astonishing in the structure of the eye than the sensibility of the expanded nerve, as proved by the extent of the changes or degrees of light which illuminate visible objects, and of which the eye is sensible; or the great degree of light which the eye can bear, and the low degree of light at which objects are visible. Thus, the proportion betwixt the degrees of light illuminating an object by the sun, and by the moon, at any equal altitudes, is calculated at 90,000 to 1.* Again, by

* See Smith's Optics, vol. i. p. 29.

M. de la Hire's calculation, we see the sail of a windmill, six feet in diameter, at the distance of 4000 toises. The eye being supposed to be an inch in diameter, the picture of this sail, at the bottom of the eye, will be $\frac{1}{8000}$ of an inch, which is the 666th part of a line, and is about the 66th part of a common hair. This conveys to us an idea of the great sensibility of the nerve in accommodating itself to such varieties in the degree of illumination: it also proves to us that the expanded nerve must have a surface mathematically correct, on which the image is represented; for how else could the image of an object be distinct, if the picture of that object in the bottom of the eye be only the 66th part of a hair in diameter?

It is evident that some guard to the eye must be furnished, in order that the organ may accommodate itself to this surprising variety in the intensity of impression. The pupil of the eye is the central perforation in the iris or curtain, which hangs before the lens. This membrane, having muscularity, is moveable: it dilates or contracts the hole or pupil which transmits the rays, so as to adapt the diameter of the stream of light, darting into the eye, to the intensity or degree of light. If a body is illuminated but faintly, the pupil is (insensibly to us) enlarged, and a greater quantity of the rays are allowed to be transmitted to the retina. As the convexity of the pellucid part of the eye, and the concentrating powers of the lens, remain the same, the size of the image is not altered by this dilatation of the pupil, but only the strength of the image or picture in the bottom of the eye increased.

We have understood that the rays of light are refracted, when they pass out of one transparent medium into another of different density.—For example, the rays of light are refracted towards the perpendicular line when they enter the cornea of the human eye; but they will be refracted in a very small degree in entering the cornea of fishes, because the aqueous humour is of the same density with the fluid from which the rays of light are transmitted; accordingly, the cornea of fishes is not prominent: it would be of no use. On the other hand, this would limit their sphere of vision, were not the deficient convexity of the cornea counterbalanced by the prominence of the whole eye, and the more anterior situation of the crystalline lens in the eye: a large pupil and greater convexity of the lens we shall afterwards find to be necessary to the distinct vision of fishes.*

It is natural, on the present occasion, to enquire into the effects of the several humours of the eye, in producing in those who are short-sighted the obscurity arising from the double appearance of small and shining points. This is prettily explained by Jurin, upon Sir Isaac Newton's principle, concerning the fits of easy refraction and reflection of light.

The horns of the new moon, or the top of a distant spire, or the lines upon the face of a clock, appear doubled or tripled, and sometimes much

* Neither fish out of water, nor other animals within water, can see any object distinctly. Divers see objects, as an old man would do, through a very concave glass put near to the eye; and it has been found, that the convexity of spectacles for divers in the sea must be that of a double convex glass, equal on both sides to the convexity of the cornea. The necessity of this is plain: the aqueous humour of the eye being of the same density with the water, there is no refraction of the rays in passing from the water into the eye, and this deficiency must be supplied.

more multiplied, to a short-sighted person. The same appearance will be given when an object is held too near the eye for perfect vision. If the light is seen through a narrow slit in a board, and the board is brought nearer to the eye than the point of distinct vision, the aperture will appear double, or as two luminous lines, with a dark line between them ; and as the distance is varied, two, three, four, or five dark and luminous lines will be observed. There are many such deceptions in viewing luminous bodies ; all of them proceed from the same cause, which is this :—Before Sir Isaac Newton's philosophy was acknowledged, it was the received opinion, that light was reflected from the surface of bodies by its impinging against their solid parts, and rebounding from them like a tennis-ball when struck against a hard and resisting surface ; further, as they saw that part of the rays of light were in glass reflected, and the rest transmitted, they conceived that part entered the pores of the glass, and part impinged upon its solid parts. But this does not account for the refractions which take place when the rays have passed the glass, and are about to be transmitted into the air : they cannot find solid parts to strike against in entering the air, for the refraction of the light is greater in passing from the glass into the air, than from the air into the glass ; and if water be placed behind the glass, the refraction of rays passing out from the glass is not increased but diminished by this substitute for the rarer medium of the air. Again, when two glasses touch each other, no refraction is made in rays passing from the one into the other. To explain this, Sir Isaac Newton taught, that, in the progress of rays of light, there is an alternation of fits of easy transition or reflection ; or, in other words, that there is a change of disposition in the rays, to be either transmitted by refraction, or to be reflected by the surface of a transparent medium. Jurin illustrates this opinion, and its application to our present purpose, in this manner.

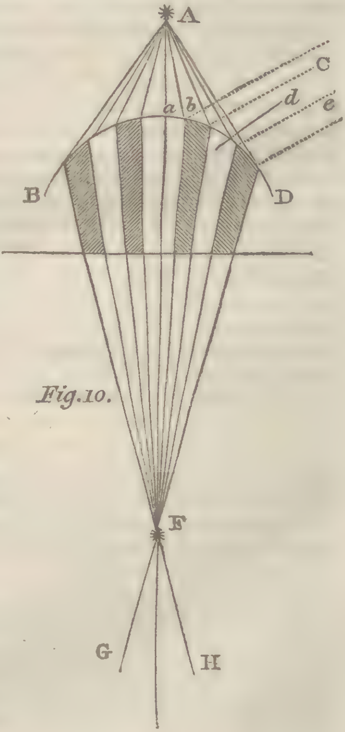


Fig.10.

Suppose that A B D, and B D F, are media of different density, and that their surfaces are intersected by the line B D ; again, let A be a pencil of rays, which, issuing from this point, falls upon B a D, as the refracting surface B a D is convex, and no two points of it, from a to D, are equally distant from the source of the rays A ; and, as the rays of light, in their progress, alter alternately from the fit of refraction to the fit of reflection, they must be in part refracted to the focus F, and reflected in the direction of the dotted lines C e. Thus, if the

ray A *a* happens to be in disposition to pass through the medium B D F, it will pass on towards the point F. If the next ray, A *b*, should not be in a fit to be transmitted, because, being in a degree farther advanced from its source A, it has changed to the fit of reflection, then it will not be refracted towards the focus F, but reflected off towards *c*; but, again, the ray A D being advanced farther from its source, it will impinge upon the surface B D, during its disposition to refraction, and will concentrate its beams at F; and so with all the others, alternately reflected and refracted.

The consequence of this obstruction to the equal refraction of light, is, that the image formed at F is feeble; but still it is distinct and perfect; because the transmitted rays are regularly concentrated, and form the proper focus. But if the converging rays should be received upon a plane before they arrive at the focus F, the reflected rays of light will have left spaces dark where they would have fallen by refraction, and, consequently, distinct luminous circles will be thrown on the plane: again, if the plane surface be opposed to the rays, after they have formed their focus, and are again dispersing after having crossed, the same unequal effect of light and dark circles will be thrown on it; though now, the rays of the right side of the pencil B D F, will form the left of the pencil F G H.

The effects of the alternate disposition of the rays for transmission and reflection would not be perceptible, did the converging powers of the cornea and lens bring the focus of the rays exactly to the surface of the retina, as in the perfect eye. But in the near-sighted person the focus is formed at a point before the retina, the rays decussate and spread out again before they form the image upon the bottom of the eye. Instead, therefore, of forming an accurate image, they are spread out into concentric circles; or, in a lesser degree, the person experiences a confused outline of the object, which becomes surrounded with several rings or false outlines.* This subject must be studied under the head of Polarisation of Light, in our philosophical books.

OF THE ANATOMY OF THE EYE STRICTLY.

THE COATS of the eye are divided into three classes.

1. The anterior and external coats; viz. The CONJUNCTIVA and the ALBUGINEA.

2. The proper coats; viz. The SCLEROTICA, the CHOROIDES, the RETINA.

3. The transparent tunics of the eye.

As the first class belongs to the external apparatus of the eye, we shall begin with the PROPER COATS.

Speaking generally, and without considering the minuter divisions of

* By *fits of easy transition*, it was not meant by Sir Isaac Newton that the rays must necessarily be transmitted through every pellucid medium, and at any obliquity of incidence, but only that the ray was more easily transmitted, and more difficultly reflected; nor was it meant that, during its *fit of easy reflection*, it was absolutely incapable of being transmitted, but only more readily reflected than transmitted.

anatomists, we may say, that there are three proper coats of the eye; viz. the SCLEROTIC COAT, giving strength; the CHOROID COAT, being the vehicle of the chief vascular structure of the eye; and the RETINA, or expanded nerve, being the seat of sense. These are the proper coats of the eye.

Although these coats may be capable of being divided by the art of the anatomist, either by the knife, by injections, which form the extravasation between their layers, by maceration, or by the chemical action of fluids; yet it is better, in a general enumeration, to take a natural division, than to enumerate all their subdivisions.

OF THE SCLEROTIC COAT.

The sclerotic coat is so called from its hardness.* The sclerotica and cornea are often considered as one continued coat investing the eye; hence they say, the opaque and the lucid cornea. But, although these parts are actually in union, yet, as they are really of so very different a nature, we must consider them apart, and treat at present only of the opaque white sclerotic coat.

The sclerotic coat is a strong, firm, and white membrane, consisting of lamellæ firmly attached and interwoven, and not capable of being regularly separated by maceration: it has the denseness of tanned leather. In firmness, whitness, opacity, and the little appearance of vascularity, it more resembles the dura mater than any other membrane of the body.

In adults, the sclerotic coat is stronger and firmer, comparatively, than in the fœtus; the cornea less so. On the outer surface, it has (towards the orbit) a loose cellular membrane attached to it, which allows the motion of the eye-ball. Upon the fore part it is invested by the tunica albuginea or tendinea. Upon its inner surface, it has a loose and soft membrane which connects it with the choroid coat.

In birds, and the tortoise, the posterior part of the sclerotic coat is thin; the fore part of it is split into laminæ, betwixt which there are interposed thin plates of bone†, while in fishes it is in part cartilaginous‡, but thin and transparent, so that there appears a very beautiful spotted coat beneath it. There are also seen in the sclerotic of fishes little white granules like glands.

The vagina of the optic nerve can be separated into two laminæ§; the outer one is observed to unite intimately with the outer part of the sclerotic coat, while the inner lamina of the vagina is contiguous with its inner surface. The pia mater, too, says Zinn, when it has pierced the foramen in the sclerotic coat, along with the substance of the nerve, expands upon the inner surface of this coat, and extends even to the cornea, and forms one of its intimate laminæ. This must be only that part of the pia mater which invests the optic nerve, or, more strictly speaking, that membrane which stands in the same relation to the nerve that the arachnoid coat does to the brain; for the membrane, which sinks into

* Dura seu sclerotica. Vesalius, Ruysch, &c.
† Cuvier, vol. i. p. 387.
‡ Morgagni Epist. An. xvi. 40. Cuvier, 388.
§ Ruysch, Zinn.

intimate union with the nerve, accompanies it even in forming the retina.*

The sclerotic coat is the great support of the globular figure of the eye: it defends the more delicate internal structure from slighter injuries, by its strength; and from the progress of inflammation, by being of a structure but little vascular, and not prone to disease. That inflammation which we see to be so frequent in the eye, is not in the sclerotica, but in the adventitious coat, the conjunctiva. But in proportion as the sclerotic coat resists pressure and the progress of disease from without, it resists the swelling of the parts within when they become diseased, and gives the greatest torture.

Of what importance the entireness of the coats, and the uniform resistance of the humours of the eye, is to the healthy state of the organ, will be afterwards examined.

OF THE CORNEA.

The cornea is so called from being firm, transparent, and composed of laminæ.† It is the pellucid circle on the fore part of the eye which seems variegated with colours; though this is a deception, owing to its perfect transparency. The circle of the cornea is, however, far from being regular; its margin is flat towards the nose. The cornea, being a segment of a smaller sphere than the eye-ball, enlarges the field of vision. The field or sphere of vision is further extended by the motion of the eye. The motion of the eye has a range of 55 degees in every direction; so that there is altogether a range of 110 degrees.‡

The cornea consists of laminæ; betwixt which there is interposed a cellular substance, filled with a perfectly pellucid fluid.§ These cells seem, like the common cellular membrane of the body, to have a free communication with each other, so that the fluid freely exudes, and as quickly is imbibed by maceration. The fulness of the cornea, with the perfect transparency of the fluid, gives a brilliancy to the eye, and is a sign of health; the reverse dims the eye, and with the fallen features accompanies ill health. Steno observed, and Petit confirmed the fact,‖

* It may be well, in this place, to mention the opinions of the chief supporter of that scheme of the coats of the eye, which derives them all from the investing membranes of the brain and optic nerve. M. le Cat, in his *Traité des Sens*, describes them thus.—When the optic nerve has entered the orbit, the dura mater which surrounds it splits into two laminæ: the external one attaches to the orbit, and forms the periosteum; the other forms the vagina of the nerve. In the angle formed by these, the muscles of the eye arise. This continued sheath of the nerve (he continues) expands into the globe of the eye, as the mass of glass is blown into a bottle. The dura mater of the nerve is expanded into the cornea (viz. sclerotica.) The second envelope, or pia mater, forms two laminæ; the one is applied to the sclerotic coat, and the other forms the choroid coat. The choroid coat divides anteriorly, and forms the iris and ciliary processes. The internal medullary part of the optic nerve forms the retina. Finally, "L'œil est très évidemment l'extremité nerveuse épanouie boursouflée en bouton creux et plein de liqueurs," p. 158. See also *Bonn* Sandifort Thesaur. de Continuatione Membranæ.

† "Cornu modo, dura, et cornu instar in laminas dividareque potest." Vesalius.

‡ Dr. Young, Phil. Trans. Nov. 27. 1800.

§ Substantia spongiosa Valsalvæ.

‖ See also Hovius, p. 82.

that the pores on the surface of the cornea exuded the fluid which fills the cells of the cornea; and that, after the surface was carefully dried by pressure, the moisture might be seen to form in drops upon the surface. The moisture can be thus forced out from the pores of either surface of the cornea.* This moisture becomes dull and clammy on the approach of death, and forms sometimes a pellicle over the cornea. The laxity with which the laminæ of the cornea are connected, may be, in some measure, demonstrated, by taking it betwixt the finger and the thumb; we shall then find, that the layers can be made to glide very freely on each other. In the fœtus, and in young children, the cornea is of great thickness, and resists the point of the lancet or scissars. This resistance in the fœtus proceeds from a great degree of toughness, while, in the adult, the surface of the cornea is so hard that I have often seen the point of the knife, in extracting the cataract, bend upon it. This turning of the elastic point of the knife is very apt to give a wrong direction to the incision.

There is a pellicle, or exceedingly thin coat, which, by maceration, can be taken off from the surface of the cornea. This is the conjunctiva continued over it.

The membrane in fishes, analogous to the adnata, lies loose over the cornea; and, in serpents, it is thrown off from the cornea, with the scales of the body, and remains attached to the cast skin of the head; and, in the fœtus calf, I have forced the blood in the vessels of the conjunctiva into the vessels passing over the surface of the cornea.

By maceration, I have found, raised in the fluid, a very delicate and transparent membrane from the inner surface of the cornea†; and, after long-continued soaking, the whole cornea can be taken out of the sclerotic coat, like an optician's glass from its frame.

The cornea possesses great sensibility; although much of the pain, from hard bodies flying into the eye, is to be attributed to the motion of the eye-lids, and the great sensibility with which they are endued. When a splinter of glass or metal strikes and sticks in the cornea, inflammation is excited: in consequence of this, vessels carrying red blood strike into it, or shoot over its surface in a new film or membrane.‡ Petit thought he observed first in a negro, and afterwards in a variety of instances, red lines in the cornea, which he conceived to be the anastomosing of vessels. There are, besides, says he, many circumstances which argue that there are blood-vessels in the cornea. When the eye receives a stroke there is often blood effused in its substance; abscesses, also, are found within it, and phlyctænæ are seen on its surface; and, in great inflammation of the eye, the cornea appears red; which, he supposed, must be produced by the same cause which makes the albuginea red, viz. the enlargement of its vessels, and the circulation of red blood. But we must not imagine, he continues, that, in the natural state, red

* Zinn.

† This, within these few years, has been claimed as a discovery. I fear that this must be considered as the capsule of the aqueous humour long since described.

‡ I have found the spark from iron in blacksmiths and masons buried in the cornea for several days (same authors say months), without exciting pain or much inconvenience. I have also more than once picked a little black slough from the cornea, mistaking it for a piece of iron, when it was only the consequence of the injury.

blood circulates in the cornea ; for the vessels are not to be seen with the microscope ; nor are they penetrated by injection ; nor do they appear in the fœtus ; nor, when little abscesses are formed in the cornea ; but only when violence has been done by a stroke upon the eye. In an eye in which the tunica conjunctiva was minutely injected, as well as the internal vessels of the eye, I observed through the microscope a set of vessels, but which, on reflection, I believe to have been only the cellular communication betwixt the laminæ of the cornea.

Vessels attach themselves both to the inner and to the outer surface of the cornea ; and when it becomes spongy and vascular in this way, little can be explained of its natural structure. Thus, the pannus and pterygium are membranes which stretch across and adhere to the cornea, while the iris frequently attaches to its inside. In this case, the cornea becomes spongy, thick, and vascular ; and, when cut, there is red blood in it* ; and in staphyloma†, the iris is generally attached to the cornea. I have a preparation in which the form and character of the iris are entirely lost : it is extended into a reticulated membrane which lines the surface of the extended cornea.

OF THE CHOROID COAT.

The choroid is the vascular tunic of the eye : it is so called from its resemblance to one of the membanes of the secundines. It is the middle coat of the eye, lying betwixt the sclerotic coat and retina. Injections show it to consist of two layers or membranes ; and it has upon its inner surface a pigment, which, being sometimes firm, might be taken for a membrane. It was Ruysch who observed this division of the choroid coat into two laminæ ; and the inner one his son called the tunica Ruyschiana : but of these hereafter.

Those anatomists who supposed the sclerotic coat to be the production of the dura mater, naturally concluded, that the choroid coat was derived from the pia mater ; and as Ruysch found it to be divisible into two laminæ, so Sladius found the pia mater to consist of two membranes. It followed that the one lamina of the choroid coat was the continuation of the tunica arachnoides, and the other of the pia mater ; but this account of these membranes has no support from observation. Betwixt the pia mater and choroid coat there is no resemblance ; the latter we shall find loaded with vessels : but these vessels are peculiar, and minister to a secreting surface. The pia mater in the brain, and optic nerve, is in strict union with the substance of the brain, and supports and nourishes it ; but the choroid coat has no connection with the retina or expanded nerve.

There can be no better mark of distinction between membranes than their degree of vascularity, and particularly in the manner of the distribution of their vessels. The choroid coat is most particular in the distri-

* Pterygium is a disease of the conjunctiva, but which resembles a membrane extended over the cornea from the canthus. Pannus is a disease of the same kind, but covering the cornea as with a white opaque membrane.

† Staphyloma uvea, viz. a protrusion and opacity of the cornea ; which from the loss of transparency, and the general appearance of the tumour, is supposed to resemble a grape.

bution of its arteries and veins. The great arterial vascularity of the choroid coat is to be seen only after a very minute injection, and the venous vascularity after artificial or accidental infarction of the blood, or by a successful injection from the superior cava*; although the very great vascularity of this coat was known to our oldest writers, yet the appearance of these vessels, when empty, has deceived many. Morgagni† and Maîtrejean have described fibres which they affirm to be distinct from the vessels, but which prove to be, in fact, the appearance presented by the collapsed vessels.

The great peculiarity of the choroid coat is its being a secreting membrane; by which I mean that the pigmentum nigrum, which is applied to the fine external membrane of the retina, being a secretion, the choroid coat has necessarily that peculiar structure of vessels which belongs to the secreting membranes. This structure has enabled anatomists to tear it into laminæ. For that part of the choroid coat next the sclerotic is merely a vehicle of vessels and nerves, and is a tissue of them connected by very fine cellular membrane. The internal part, again, is organized into a secreting surface, and is the tunica Ruyschiana.‡ I conceive, that the division into the choroid coat, and tunica Ruyschiana, is warranted from the nature of the membrane, as the divisions of the coats of the intestines are.§

Morgagni says, that, from his earliest youth, he had many proofs that the choroid coat was not single in brutes; he asserts, also, that Franciscus Sylvius and Guenellonius had demonstrated the double laminæ of this membrane before Ruysch.|| Certain it is, that Ruysch was not so fortunate in ascribing a use to this tunica Ruyschiana. He supposed that it gave strength to the choroid coat, and, by bringing a greater afflux of arterial blood, supplied the necessary heat to the otherwise cold humours.¶

Tapetum.—The internal surface of the choroid coat has been long called tapetum, from its villous or fleecy appearance when seen through the microscope. This surface in the adult is of a brown colour; in very young subjects it is red and bloody; and, when minutely injected, it is like scarlet cloth. It is by this vascular surface or tapetum that the black pigment, which is laid under the expanded retina in the human eye, is secreted.

The pigmentum nigrum.—The pigmentum nigrum is the black or deep-brown mucous substance which lies between the choroid coat and retina. It is of a nature to be washed away with a little water and a soft pencil.** This brown taint pervades the whole texture of the choroid

* An observation of Walter.

† Morgagni Epist. Anat. xvii. 2.

‡ Ruysch. Epist. Anat. xiii.

§ Albini Annot. Acad. lib. vii. cap. iv.

|| Morgagni Epist. Anat. xvii. 3.

¶ Quod ad usum tunicæ Ruyschianæ attinet crediderim hanc tunicam inter cæteros usus esse destinatam, non solum ad robur choroidæ verum etiam ut a sanguinis arteriosi majori copia requisitus calor tribus humoribus natura frigidus conciliaretur. Ruys. Respons. ad Christ. Wedelium, p. 14.

** I cannot conceive how this matter should be confounded with the tapetum or tapis, which, as the same implies, is the villous surface of the choroid coat. Tapetum is properly, cloth wrought with various colours; and the analogy was first used by the

coat. It is in immediate contact with the exterior membrane of the optic nerve. Its use is apparently to stifle the rays of light after they have struck on the sensible surface of the retina; for we know that blackness is owing to the absorption of the light, as whiteness and colour is the reflection of it from the surface of bodies. The dark colour of the secreted pigment of the choroid coat is, in some measure, peculiar to those animals which see in the brightest light of day; but is wanting, or of a bright reflecting green or silvery whiteness, in such as prowl by night. The natural conclusion, therefore, is, that the pigmentum nigrum subdues the intensity of the impression, while the reflecting colours of the surface in animals which see during the night, strengthen the effect of the light on the surface of the retina, by repelling it. As fishes have the other provisions for seeing in an obscure light, they have also this of the reflecting surface of the tapetum: as it is a secretion of the villous surface of the choroid, we see why it becomes somewhat deficient in old men, and sometimes wanting in the degenerate varieties of animals; when entirely deficient, the blood circulating in the vessels of the choroid coat gives a lurid redness to the reflections from the bottom of the eye.*

Finally, in regard to the choroid coat, we have to understand that it consists of two laminæ: the outer, and that which is next to the sclerotic coat, being the proper choroid; the internal lamina, the tunica Ruyschiana: that on the surface of the tunica Ruyschiana there is a pile or fleece, which is called tapetum: and, lastly, that the secretion of this inner surface is a pigment, which, in the human eye, has the appropriate name of pigmentum nigrum; but, in many animals, it is of a silver, golden, or Isabella colour; though, in my apprehension, the colour, in all these varieties, depends still upon a peculiar secreted matter.

ANNULUS LIGAMENTOSUS.

When we take away the sclerotic coat from the choroides, we see at the termination of the choroides, forward in the iris, a white ring: this should be called the ciliary ligament: it is the bond of union betwixt the choroid coat, the iris, and corona ciliaris. Sœmmerring calls this the annulus gangliformis tunicæ choroideæ.

OF THE CILIARY PROCESSES, OR CORONA CILIARIS.

The ciliary processes are formed of the anterior margin of the choroid coat: they give the appearance as if the choroid coat, at the anterior

French Academicians, in the account of their dissection of a lioness. "The mem-"brane which is put into the bottom of the eye, and laid on the choroides, which we "call the tapetum, was of an Isabella colour, intermixed with a greenish blue. It was "easily separable from the choroides, which remained entire, with its ordinary thick-"ness, after that we had taken away the membrane which forms the tapetum." The explanation of this, I suppose, will be found in Morg. Epist. An. xvii. 3.

* As the pigmentum nigrum is a secretion, we shall not be suprised to find it become deficient in the commencement of some diseases of the eye. This is known by the possibility of seeing to the bottom of the eye; that is, the choroid coat becomes a reflecting surface, and throws out the beams like a cat's eye. See Med. Observ. and Enquiries, vol. iii. p. 124.

part, were folded inward to the margin of the crystalline lens ; and as if, to accommodate it to this sudden inflection, it had been plaited, and not regularly contracted ; at least, this is much the appearance of the circle of ciliary processes, when, after cutting across the eye, we look from behind upon the lens in its natural situation. In this view, we find the pigmentum nigrum of the choroid coat continued over the ciliary processes, which gives to them the appearance of the regular plicæ of the choroid coat, converging to the edge of the lens, and forming altogether a disk round it.

When the black paint on the ciliary processes is a little washed away, and when we attentively examine this part, we find the ciliary processes to be actually little oblong plicæ, which gradually arise from the choroid coat at the angle of its inflection, and terminate abruptly, approximating, but not attached, to the margin of the lens. When the paint is washed entirely away, the whole circle of these processes appears evidently to be the continued choroid coat.

When not injected, the ciliary processes are pale and loose ; but, when minutely injected, they take a perfect scarlet colour : they resemble, in their uninjected state, the valvular-like doublings of the villous coat of the stomach and intestines. Before the choroid coat is inflected towards the lens, in the form of ciliary processes, it forms a firm adhesion to the sclerotic coat near the circular margin of the cornea, and at the same time is united firmly to the root of the iris forming the annulus ligamentosus. From this, the processes tend inward, and a little backwards ; and are, at their external extremities, detached from the iris ; nor are they attached to the margin of the lens, but are loose and floating.

When the vitreous humour and lens fall out from the anterior segment of the eye, we find that the plicæ or ciliary processes have left their impression on the anterior surface of the vitreous humour, and also on the intermediate expansion of the retina which extends before the membrane of the vitreous humour. This circular impression of the ciliary processes is called by Haller, striæ retinæ subjectæ ligamento ciliari.* I have called this impression HALO SIGNATUS, because it is produced by a circle of radiations, formed by the impression of the ciliary processes, and is not peculiar to the retina, for the retina again makes its impression on the membrane of the vitreous humour. The furrows and doublings of the anterior part of the retina, formed by the impression of the ciliary processes, Dr. Monro has called the ciliary processes of the retina ; but, for my part, I think this a term likely to confound and mislead a student ; and we might as well speak of the ciliary processes of the vitreous humour, or of the membrane of the vitreous humour, since they also take the impression of the ciliary processes.†

When the vitreous humour and lens are taken out of the coats, we see also that the ciliary processes have left the stain of the black paint.‡

* Fasc. vii. icon. ocul.

† Winslow uses the term sulci ciliares, for the impression on the vitreous humour. Zinn calls this corona ciliaris, after Camper : he describes them well, p. 75.

‡ See Morgagni Epist. Anat. xvii. n. 13. and Ruysch also, " Nonnulli pro processu ciliari agnoscunt pullas pigmenti nigri reliquias, membranulæ tenuissimæ humoris crystallini et vitrei, et quasi fibres mentientes, oculo sc. aperto, humoribusque exemptis ;

This it is necessary to remark, since I have seen students confound this mark with the ciliary processes themselves. The ciliary processes are of a most elegant vascular structure. Their contorted arteries are beautifully represented in Zinn's figure. He traces them from the extreme branches of the choroid coat; but, of their veins, he says nothing further than that they are continued from the branches of the vasa verticosa, or veins of the choroid coat. The points of the ciliary processes are not attached to the lens, but float loose in the posterior chamber of the aqueous humour*; but, at a little distance from their points, they adhere to the retina, where it is continued over the anterior part of the vitreous humour. Through this attachment only are they connected with the lens; for, as we shall find presently, the retina (as a membrane, but not as the sensible retina,) is continued over the crystalline lens.†

SŒMMERRING [*Icones oculi humani*] describes the retina as spontaneously falling off and separating from the exterior circle of the *corona ciliaris*. But he also has mistaken the nervous matter which stops here for the whole retina. The transparent tunica vasculosa retinæ proceeds to the lens.

The ciliary processes, collectively, form a circle round the lens, which I call corona ciliaris. This circle forms a perfectly opaque partition, which stifles all rays that might otherwise be transmitted by the side of the lens. The corona ciliaris, or ciliary circle, no doubt, serves at the same time as a connection between the outer and strong coats of the eye and the transparent coats and humours; for, it is to be observed, that, excepting the connections which naturally exist between the optic nerve and retina, this slender hold which the ciliary processes take of the expanded retina, is the only attachment betwixt the humours of the eye and the proper coats.

In regard to the names appropriated to this part of the eye, there is more confusion than it is possible to believe. It is necessary to attend to this ambiguous use of terms, else we shall be in danger of misunderstanding our best authors. Vesalius considers the whole as a septum betwixt the vitreous and posterior chamber of the aqueous humour; but he seems to find much difficulty in giving it an appropriate name.‡ Fallopius and Morgagni§ use the term CORPUS CILIARE for the whole circle of the processes, and in the same sense that I have ventured to use corona ciliaris. It is a name which conveys the idea neither of the shape nor of the substance of the thing meant. Ruysch makes great confusion by his use of terms: the corona ciliaris, or ciliary body, he calls the ligamentum ciliare; and the lines on the back surface of the iris, he calls processus ciliaris musculosus; or, rather, he means by this,

hæ autem nil sunt nisi avulsæ particulæ pigmenti nigri." Ruysch. Thes. An. ii. Ass. 1. No. xv.

* This was demonstrated in a particular manner by Ruysch and Morgagni.

† Zinn and other later writers have entertained the idea that the adhesion of the ciliary processes to the membranes covering the vitreous humour is by a kind of gluing, rather than a union by cellular membrane. See Zinn, p. 75.

‡ "Neque mihi ullum occurrit nomen quod ipsi aptius indam quam tunicæ; aut, si voles, interstitii vel septi inter vitreum humorem et eum quem albugineum nuncupamus repositi." Vesal. vol. i. p. 558.

§ Epist. Anat. xvii. 11.

the straight fibres of the iris.* Duverney, with Ruysch and Winslow, following Fallopius, calls the corona ciliaris also ligamentum ciliare. But the ciliary ligament is used by others in a widely different sense, viz. for the circular root of the ciliary body and iris, the annulum album cellulosum, or the frenula membranosa of Zinn. By Hovius, what I have called halo signatus is called ligamentum ciliare. In Haller's fifth figure of the eye, this circular root of the ciliary processes is called orbiculus ciliaris. Maîtrejean, Haller, and others, call the whole body, or corona, the ciliary circle; M. Ferrein, "l'anneau de la choroide;" and M. Lieutaud denominated the ciliary processes, "rayons ciliares," and the root of the corona ciliaris and iris, "plexus ciliaris."

OF THE IRIS.

The iris is the coloured circle which surrounds the pupil, and which we see through the transparent cornea of the eye. It is a membrane hung before the crystalline lens.† It is perforated in the middle; and this hole in the middle of the iris is the pupil; and through the pupil only can the rays be transmitted to the bottom of the eye. When we hear of the dilatation and contraction of the pupil, it is an inaccuracy of language: we have to understand the action of the iris, which, by possessing the power of contracting and spreading out, diminishes or enlarges the pupil, and so holds a control over the quantity of light transmitted to the bottom of the eye. For, by the extension of this membrane, the diameter of the pupil is diminished, and by contraction of the membrane it is enlarged. This motion of the iris, and, consequently, the size of the pupil, is connected with the sensation of the retina; by which means, in disease of internal parts of the eye, it is often an index to us of the state of the nerve, and of the possibility of giving relief by operation.

The iris and corona ciliaris, or ciliary processes, are, in general, considered as being the two laminæ of the choroid coat, continued forward and split: the internal lamina of the choroid forming the corona ciliaris, and the outer one forming the iris. The former I was willing to consider as the anterior margin of the choroid coat, because it has no

* Ruysch has this expression:—"Ligamentum ciliare neutiquam esse considerandum tanquam musculum ad pupillæ et humoris crystallini motum destinatum, totumque hoc negotium perfici a processu ciliari ut et a circulo musculari posterius in confinio pupillæ sito." Thes. Anat. ii. xv. See also the explanation of fig. iv. of this Thesaurus, where we have, "Iris enim est facies exterior, processus lig. ciliaris facies interior."

† Winslow and Haller, and most of the old anatomists, call this UVEA; by which they mean to imply that it is a part of the choroides. See Ophthalmographia, Auctore G. Briggs, Cantab. 1676: but most of the modern anatomists follow Zinn and Lieutaud in calling it iris; though Lieutaud and others call the anterior surface only iris, while they still continued to call this perforated membrane choroides, or uvea. See Lieut. p. 117. Again, others call the posterior surface of the iris uvea, from its likeness to the dark colour of a raisin; and the word iris is borrowed, I suppose, from the varied colours of the rainbow on its anterior surface.

distinction in its structure from that coat; but the iris I cannot consider as the continued choroid coat; in the *first* place, because I have found it fall out a perfect circle by maceration; *secondly*, because it has no resemblance in structure to the choroid coat; and, *chiefly*, as, by its power of contracting, it shows quite a different character from any of the other membranes of the eye.

The outer surface of this circular membrane gives the colour to the eye during life; and, from its beautiful and variegated colours, it has gained to the whole membrane the name of iris. Haller and Zinn, nearly at the same time, explained the cause of this colour of the iris, which had been, till then, supposed to be occasioned by the refraction of the light amongst its striæ and fibres. When this membrane is put in water, and examined with the microscope, its anterior surface is seen to be covered with minute villi. The splendid colouring of the iris proceeds from the villi; but, by beginning putrefaction, the splendid reflection fades, as the brilliant surface of the choroid of brutes is lost by keeping. For this reason, I imagine the colour and brilliancy of the iris to depend on the secretion from these villi. But the colour of the iris depends, in a great measure, on the black paint upon its posterior surface shining through it; and the black and hazel-coloured eye is owing to the greater degree of transparency of the iris, which allows the dark uvea to shine through it.

The iris is acknowledged to be the most acutely-sensible part in the body. We have, then, to expect in its composition muscular fibres, and to account for its acute irritability and sympathy by a profusion of nerves: again, as the power of the muscular fibre, and the sensibility of the nerve, are both, in some measure, indebted to the circulation of the blood, we may expect to find also a profusion of vessels in the iris. In all these respects we shall find the iris to be an object of admiration.

OF THE MUSCULAR FIBRES OF THE IRIS.

It is evident from a note, under the head corona ciliaris, that Ruysch had observed two sets of muscular fibres in the iris; for, under the name of ciliary ligament, he describes a set of radiated fibres which go from the ciliary processes towards the circular margin of the pupil: he observed, also, the circular or orbicular fibres which run round the margin of the pupil. Winslow says, that between the two laminæ of the uvea (viz. iris) we find two thin planes of fibres, which appear to be fleshy: the fibres of one plane orbicular, and lying round the circumference of the pupil, and those of the other being radiated; one extremity of it being fixed to the orbicular plane, the other to the great edge of the uvea. Zinn describes, with much minuteness, radiated fibres (on the anterior surface of the iris), but does not consider these as muscular fibres; and he confesses, that he could not observe the orbicular muscle which Maîtrejean and Ruysch had painted. Even in owls and other creatures, having a strong iris, he could not discover an orbicular muscle; nor were Haller and Morgagni more successful in this investigation.*

* See Zinn, p. 89. and 90. Morgagni Epist. Anat. xvii. § 4. Haller and Ferrein attribute the motion of the iris to an afflux of humours in its vessels.

Wrisberg also affirms, that no muscular fibres could be seen in the iris of the ox. Dr. Monro, on the other hand, adheres to the opinion of the muscularity of the iris: he describes minutely both the radiated and sphincter fibres. Wrisberg and others have thought they found sufficient proof against the muscularity of the iris, in the fact of its not contracting when the light falls upon its surface. To this Dr. Monro answers, that the colour or paint upon the iris must, like a cuticle, prevent the light from irritating the iris. I cannot think that this circumstance should prevent the excitement of the iris. The retina is in a peculiar manner susceptible of the impression of light; but we cannot wonder that light should not stimulate a muscle to contraction, when we have every proof that it has no effect on the most delicate expanded nerve of the other senses.

That the iris is to be affected only through the sensation of the retina, communicated to the sensorium, we have sufficient proof. I have, in couching, repeatedly rubbed the side of the needle against the iris without exciting any motion in it; I have seen it pricked slightly by the needle without its showing any sign of being irritated; nay, what was, too, a convincing proof, I have seen it cut by falling before the knife in extracting the cataract. In this last instance, far from being stimulated to contraction, it hung relaxed.*

It is evident, then, that no common stimulus, immediately applied to the iris, has any sensible effect in exciting it to contraction; and that it is subject to be influenced, in a secondary way, by the degree of intensity of light admitted to the retina. The movement of the iris is in general involuntary; but terror and sudden fright affect it. In some animals, particularly in the parrot, it is a voluntary muscle.† As an object upon which we look approaches the eye, the pupil contracts, which is an effect of the increasing intensity of the light reflected from the object; for, as we observed before, as the object advances, it fills a greater space in the sphere of vision, and, of course, more rays flow from it into the eye.

Nerves of the iris.—The iris is supplied with nerves in great profusion. They are derived from the long ciliary nerves which run forward betwixt the cornea and choroid coat towards the common root of the corona ciliaris and the iris. They there divide, and are seen to pass in numerous branches into the substance of the iris. In the substance of the iris, the branches of the nerves, from their extreme minuteness, are soon lost amongst its pale fibres.

Blood-vessels of the iris.—I have had preparations which showed so great a degree of vascularity in the iris, that I was ready to believe

* This fact destroys the hypothesis of M. Mery, of the Royal Acad. of Sciences, that the straight fibres of the iris are little cavernous bodies, and that the action of the light upon the retina swelled and elongated them so as to cause the diminution of the size of the pupil; for, by this cut, they must have fallen from their erected state, and contracted so as to have dilated the pupil. See Acad. Roy. des Sc. 1704, Mem. p. 261.

† When a cat is roused to attention, as by the scratching of a mouse, it dilates the pupil, which allows a stronger impression on the bottom of the eye; nay, whenever puss struggles violently to get loose, the pupil dilates, which may sufficiently account for M. Mery's cat having her pupil dilated when he plunged her under the water. See Acad. Roy. des Sc. 1704, Mem. p. 261.

its action to be produced entirely by a vascular structure ; but when, on other occasions, my admiration was excited by the profusion of nerves, and I was led to observe that in the former instances they had been obscured by the injection, I could not but allow that the muscular fibres might have been obscured as the nerves were.

There are four arteries sent to the iris : two long ciliary arteries, which take a long course on the outside of the choroid coat ; and two lesser and anterior arteries, which pierce the ligamentum ciliare from without. These arteries approach the root of the iris at four opposite points, and, branching widely, form a vascular circle round the root of the iris, viz. the larger circle of the iris. From this circle branches pass off, which run with a serpentine course, converging to the edge of the iris : here they again throw out inosculating branches, which form a circle surrounding the pupil, but at some little distance from the edge of the iris ;—this is the lesser circle of the iris. From this lesser circle there again proceed minute branches towards the edge of the iris.*

The VEINS, which intermingle their branches with these arteries, pass some of them into the vasa vorticosa of the choroid coat, and others take a long course betwixt the choroid and sclerotic coat, accompanying the ciliary nerves ; whilst some branches pierce the sclerotic coat at the root of the iris, and become superficial upon the fore part of the eye.

It was at one time believed, on the authority of many excellent anatomists, that the vessels of the iris were colourless, and did not circulate red blood : after what has been said, it is scarcely necessary to notice the fallacy of this opinion.† I have seen the iris cut and bleeding, though not profusely, as I expected ; the small quantity of blood soon coagulated into a dark speck, while I expected it should have been effused in the aqueous humour.

OF THE RETINA,

AND DIGRESSION CONCERNING THE SEAT OF VISION.

THE term retina has, in a modern publication, been objected to, as improperly applied to the inner coat of the eye. Such a term, it has been said, may well be applied to the nerve expanded on the lamina spiralis of the cochlea, because it is there formed into an intricate plexus by innumerable joinings and separations of its component parts ; but, used for the expanded nerve of the eye, the term retina is thought improper.‡ We must look for the resemblance, however, which justifies this term, not in the medullary matter of the nerve, but in its vessels.

* See Ruysch. Epist. Anat. Prob. xiii. p. 31.

† Dr. Monro, in treating of this subject, mentions his having seen a net-work of vessels covered with paint darker than that of the iris, and extended from the iris upon the surface of the lens ; and, in another instance, a net-work of filaments passing quite across the pupil. See his Dissertations, p. 108.

‡ Dr. Monro's 4to. Treatises.

"Hanc figuram egregie repræsentat dicta tunica retina cum arteriolæ ceracea materia sunt repletæ."*

The retina is the expansion of the optic nerve, the immediate seat of sensation, and the most internal of those membranes which are called the coats of the eye. It has been already observed, that there is a distinction betwixt a nerve in its course from the brain to the organ of sense, and where it is actually expanded and adapted to the reception of the external impression. Before the optic nerve has perforated the sclerotic coat of the eye, it is surrounded with a firm sheath; and its substance is evidently composed of bundles of fibres, though not so coarse, yet like those of the nerves in the other parts of the body. The opacity of the nerve makes it have little the appearance of vascularity; but, when the body of the nerve is made transparent, it becomes like a red cord; so necessary is it that the medullary substance of the nerve be supplied with blood.

The stronger sheath which surrounds the body of the optic nerve is loose, and may be separated into lamellæ. There is a more delicate membrane, which immediately adheres to the surface of the nerve; and its substance is formed into the minute fasciculi, which give it the fibrous appearance by a still firmer intertexture of membrane. This interwoven membrane proceeds, with the retina, into the eye; the other sheaths are reflected off, and unite with the sclerotic coat. Some little way from the back part of the eye, the arteria centralis retinæ pierces the sheath of the nerve, plunges into the centre, and passes into the eye along with it. If the optic nerve be cut near to the eye, the open mouth of this small artery may be seen; but if we make our section some way removed from the back of the eye, it will, of course, not be seen. The space left by the artery contracting in the centre of the nerve, when thus cut, (or, perhaps, it was the open mouth of the artery itself,) was observed by the ancients, and by them called the porus opticus: they were ignorant of this central artery of the retina.†

Where the optic nerve is about to enter into the ball of the eye, it is much diminished in diameter: it is contracted and condensed, and, at the same time, lays aside the strong coats. The proper nerve then perforates a cribriform lamina in the sclerotic coat. Within the eye, the filaments seen in the nerve are no longer distinguishable; but from the extremity of the nerve the fine web of the retina is produced.

The LAMINA CRIBROSA, and the delicate fasciculi of the optic nerve, are shown in this manner: after making a section of the eye, wash away the retina from the extremity of the optic nerve, and also the choroid coat; then press the optic nerve betwixt the finger and thumb, when the pulp of the nerve will be seen to protrude through the foramina in the sclerotic coat like white points. It is observed by Zinn, that, in doing this, there is a central foramen which remains unfilled up by the compression of the

* Ruysch. Epist. Anat. xiii. p. 11. Quamobrem servare adhuc retinæ, appellationem si non ex fibrarum ut certe ex vasorum implicatione, &c. Morgagni Epist. Anat. xvii. § 43.

† Porum opticum Hierophilus et omnis ab ea antiquitas dixit, foramen nempe quod in dissecto nervo de vacua arteria superest. Hall. Arter. Ocul. Hist. p. 42. De Vasis Nervi Optici, vide Ruysch. Epist. Anat. xiii. tab. xvi. Albinus Acad. Anat. lib. vii. c. vii.

nerve. This is the hole perforated by the arteria centralis retinæ.* Where the threads of nerves are accumulated after passing these foramina, and before they are finally expanded into the retina, they necessarily form a small cone or papilla. This conical form of the extremity of the optic nerve is much more evident in some animals than in others; but in a section of the human optic nerve we may also observe it.†

The retina is a membrane of the most delicate texture of any in the animal body: it is transparent in the recent state, and so soft, that it will tear with its own weight. In spirits and weak acids, it becomes opaque and firmer. It lies expanded over the vitreous humour, and contiguous, but not adhering, to the choroid coat, or its pigment. The retina does not consist merely of the expanded nervous matter, but has in its composition two very fine membranes, and many minute vessels. This part of my subject brings me to the beautiful discovery of Dr. Jacob of Dublin, of a new membrane or layer of this coat of the eye. If the sclerotic and choroid coats of the eye be dissected off a recent eye, and the retina disclosed, and especially if this be done under water, a fine film may be seen to rise and float from the outer surface of the retina. The pulp or proper nervous matter of the retina is retained between the two membranes, the tunica vasculosa retinæ on the inside, and the newly-discovered membrane on the outer surface. Zinn, it may be perceived from the note below, had no idea of such a separation being possible. When the retina is macerated for a considerable time, the pulp of the nerve can be washed away, and there remains only the reticulated and delicate membrane, which supports the vessels that nourish it. But, though the pulp of the nerve may be dissolved, it cannot, by dissection, be freed from the membranes which support it on the inside.‡

I have a preparation which more resembles some of Ruysch's plates than any I have seen; in it, the nerve being washed away, we may see distinctly the whole course of the arteria centralis retinæ. Of this preparation I have given an engraving, to show how plentifully this organ is supplied with red blood; from which circumstance we may learn the strict dependence of its function on the circulation, and sometimes we may deduce the derangement of the powers of vision as a consequence of the disordered action of these vessels.

The outer membrane of the retina is transparent, but the proper matter of the nerve is opaque in the dead subject, and the opacity of the nervous matter prevents the vessels of this coat being seen when we look

* Zinn de oculo humano, p. 106. Com. Reg. Soc. Scient. Gotting. log. cit. About thirty foramina have been observed in the lamina cribrosa. See Haller Fasc. de Arter. Oculi, p. 42.

† Zinn. "At the place which answers to the insertion of the optic nerve, we observe a small depression, in which lies a sort of medullary button terminating in a point." Winslow, p. 78.

‡ "Posse vere medullarem retinæ laminam removeri ut vasculosum rete membranæ figuram retineat, alteramque ab altera integram detrahi ultra hominum artem positum esse videtur nec ulli unquam contigisse legere me memini, etsi, deleta macerendo medulla, rete vasculosum laminam peculiarem referre videatur. Ex quibus omnibus elicio retinam esse tunicam simplicem, ex cellulosa conflatam: que vascula et substantiam medullarem sustinet etsi duas diversas ostendat facies alteram vasculosam interiorem, alteram medullarem exteriorem." Zinn, p. 112.

upon the outer surface* for the vessels of the retina run upon the surface contiguous to the vitreous humour.† The arteria centralis retinæ is derived from the ophthalmic artery. It pierces the optic nerve, as we have already observed, and enters the eye through the porus opticus, to supply the retina. But the arteries of the retina do not always enter into the eye in one trunk; on the contrary, sometimes two or three branches pierce the lamina cribrosa‡, and afterwards, two, three, or four principal branches, spread out on the circumference of the retina; from these, the ramifications are so numerous, that Ruysch describes them as constituting the membrane.§ Corresponding with the arteria centralis retinæ in the adult, there are veins, the minute extremities of which, after forming connections with the veins of the corona ciliaris, run backwards on the inner surface of the retina in three or four distinct branches. These, uniting into a trunk, perforate the lamina cribrosa, and become the sociæ arteriæ centralis.

Many have been led to believe, that the retina terminates forward on the roots of the ciliary processes; others have conceived it to be continued over the fore part of the vitreous humour, and over the surface of the lens.|| The most prevalent opinion is, that it terminates on the margin of the lens. Correctly speaking, there is no termination to a proper membrane: I know no instance of it. That the retina, considered as the organ of sense, extends over the back of the lens, and receives there the impression of light, is very improbable; but that the membrane, which supports the nervous matter, is continued over the lens, is demonstrable. I have said above, that the retina consists of two distinct parts, viz. the medulla of the nerve, and pellucid membranes supporting it. It is by most anatomists believed, that the retina passes forward betwixt the vitreous humour and corona ciliaris, and adheres to the margin of the lens. Now, as this adhesion is not a gluing together of parts, but a union or intermixture of membraneous filaments, the interchange and mingling of fibres, we may safely say, that the membrane of the retina is continued over the lens, and forms part of its capsule. The opacity

* "C'est surtout dans les poissons qu'il est facile de distinguer, et même de séparer, ces deux lames." Cuvier, tom. ii. p. 419.

The opacity of the outer surface of the retina prevents the vascularity from being apparent. Albinus, after a very minute injection, observed, that when he lifted up the choroid coat, the vascularity of the retina was not seen: "Autem de ea aliquid acuto scalpello subtilliter levissimeque deradens, mox conspicio vasa impleta multa quæ sub medulla cujus nimirum portionem deraseram latuerant." Albin. An. Acad. lib. iii. cap. xiv.

† Dr. Monro has these words, expressive of an opposite opinion: "The whole appears to be composed of an uniform pulpy matter, on the outer side of which chiefly vessels are dispersed, supported, I suppose, by a membrane the same or analogous to the pia mater." 4to. Treatises on the Eye, Ear, &c.

‡ Haller loc. cit. Morgagni Ep. Anat. xvii. n. 44., nor do they always pierce the centre of the nerve exactly. Morgagni.

§ "Iteratis perscrutiniis reperio oculis armatis arteriolarum extrema tam esse numerosa et tam arcte sibi invicem et intricate annexa ut peculiarem representent membranulam ex arteriolarum extremis constitutam, cui connectetur dicta medullosa substantia." Ruysch. Epist. Anat. xiii. p. 15.

|| Many anatomists, Winslow, Cassobohm, Ferrein, Lieutaud, and Haller, have taught that the retina extends over the great convexity of the lens, or that it is inserted into it. Galen believed it to extend over the lens. For an impartial history of opinions, see Morgagni Epist. Anat. xvii. 47. and Zinn, 114.

of the retina is diminished at the root of the ciliary processes, and disappears altogether at the margin of the lens; and here it is not only changed by becoming perfectly transparent and allied to the membranes of the humours, but it becomes also distinguishable from the opaque retina by a greater toughness and strength. The continuity of the retina with the capsule of the lens is more apparent, when both membranes have become opaque by being immersed in spirits or vinegar, but more particularly when that opacity is produced by disease. In disease, I have found the veins of the retina running over the margin of the lens, and branching on its posterior convexity.

THE FORAMEN OF SŒMMERRING.

When a student in Edinburgh, I found, on dissecting a recent human eye, a yellow spot on the retina of an irregular figure. I noticed that it was opposite the pupil, and conceived it to be a disease of this part of the nerve. I preserved the preparation carefully. When the discovery of Sœmmerring was made known to me I found my mistake, and that this curious spot was a natural appearance.* Sœmmerring describes the appearance as a foramen, surrounded with a yellow edge. But it is not a foramen: the pellucid membranes are not *perforated;* the appearance is a consequence of the imperfect opacity of a point in the centre of the yellow spot. He describes, too, a fold, which hangs over the hole, and tends to conceal it. In my preparations, the foramen is on the prominence of this fold. The existence of this fold in the living eye has been disputed. Blumenbach thinks he has got a use for this *hole.* He supposes that it expands and contracts: but how this is " to prevent the inconvenience of too intense a light," I cannot, as yet, comprehend.†

Where the retina lies betwixt the vitreous humour and the ciliary processes, it is plaited, and descends into the interstices of these processes.

When we take off the sclerotic and choroid coats of the eye, by dissecting them round the insertion of the optic nerve, and fold them back, carefully preserving the retina; and, when we have taken away the ciliary processes from their adhesion to the fore part of the retina, we find the retina to form a sac surrounding the vitreous humour, and attached to the lens. In all this surface the membrane is smooth and uninterrupted, and up to the margin of the lens all this sac is opaque; because the nervous matter contained betwixt the membranes is opaque,

* Sœmmerring De foramine centrali limbo luteo cincto retinæ humanæ.—*Comment. Soc. Reg. Scien. Gotting.*

† The *foramen* of Sœmmerring, or *foramen centrale retinæ*, was discovered by Baron Sœmmerring in the human eye, about the year 1795. He described at the same time a yellowish margin, partly surrounding it, and a fold of the *retina* close to it. The structure was at first supposed peculiar to man, but was soon after shown by Cuvier and Michaelis to be present in the *Quadrumana:* it has since been discovered by Dr. Knox to be present in the *Cameleon*, and in certain species of the lizard, as the *Lacerta superciliosa*, &c. The *foramen* is larger in the *Cameleon* than in man: it occupies the same relative situation with regard to the entrance of the optic nerve, and is exactly in the line of vision. The margin is not yellow. Dr. K. affirms, that the fold generally described in the human retina is a *post mortem* appearance. See his papers in the Transactions of the Royal Society of Dublin, and of the Wernerian Society of Edinburgh.

but the coats of the lens are transparent, yet continuous with the arachnoid portion of the retina. When these parts of the eye are thus dissected, they hang all together by the optic nerve; viz. the lens, the vitreous humour, and the expanded matter of the nerve, and the organ is divested only of its outer apparatus: we still retain within this sac the more essential and important parts.

There is here a natural division; and I am willing to pause upon this, knowing well with how much difficulty the student gains a knowledge of the minute structure of the eye. All within the connections of the retina I shall call the INTERNAL GLOBE of the eye, as distinguishing it from the outward coats of the eye, and parts subservient to them. A view of the little vascular system of these internal parts, thus classed, will show how strictly they are connected together, and how much insulated from the other parts.

But this is a subject upon which we cannot enter until we have considered the nature and relative situation of the humours of the eye.

DIGRESSION ON THE SEAT OF VISION.

M. l'Abbé Marriotte discovered the curious fact, that when the rays fall upon the centre of the optic nerve, they give no sensation. He describes his experiment in this manner:—"Having often observed, in dissections of men, as well as of brutes, that the optic nerve does never answer just to the middle of the bottom of the eye; that is, to the place where the picture of the object we look directly upon is made; and that in man it is somewhat higher, and on the side towards the nose: to make, therefore, the rays of an object to fall upon the optic nerve of my eye, and to find the consequence thereof, I made this experiment. I fastened on an obscure wall, about the height of my eye, a small round paper, to serve me for a fixed point of vision: I fastened such another on the side thereof towards my right hand, at the distance of about two feet, but somewhat lower than the first, to the end that I might strike the optic nerve of my right eye while I kept my left shut. Then I placed myself over against the first paper, and drew back by little and little, keeping my right eye fixed and very steady upon the same, and, being about ten feet distant, the second paper totally disappeared."*

This defect in the vision of the one eye is corrected by that of the other; for the insertion of the optic nerves being towards the side next the nose, no part of an image can ever fall on the optic nerve of both eyes at once; the defect of vision, therefore, is observed only in very careful experiments. Experiments were, however, made by M. Picard, Marriotte, and Le Cat, to render this effect produced by the image falling on the centre of the optic nerve evident, when looking with both eyes. Marriotte's second experiment was this:—Place two round pieces of paper at the height of your eyes, three feet from one another; then place yourself opposite to them at the distance of 12 or 13 feet, and hold your thumb before your eyes at the distance of about eight inches, so that it may conceal from the right eye the paper that is to the left hand, and from the left eye the paper to the right hand. If, now, you look at your

* Vide Phil. Trans. No. 35. Smith's Optics, Remarks on, art. 87.

thumb steadily with both eyes, you will lose sight of both the papers.* The novelty of such a discovery was likely, as frequently is the case, to carry men's minds beyond the true point. It requires time for such facts to descend to their level in the scale of importance, with other less novel observations. Marriotte, upon this fact, formed a new hypothesis relating to the seat of vision. We have observed, that the choroid coat and pigmentum nigrum are deficient where the optic nerve enters the eye and is about to expand into the retina. He fixed upon the most unaccountable supposition, that the retina does not receive the impression of the rays, but that the choroid coat is the seat of the sense. In support of this theory, he soon found other arguments than those arising from the deficiency of the choroid coat at the entrance of the nerve. He saw that the pupil dilated in the shade, and contracted in a more intense light: now, says he, as the iris is a continuation of the choroid coat, this is a proof of the great sensibility of that coat: again, the dark colour of the choroid coat he supposed to be well calculated for the action of the rays of light, which are not reflected from it, or transmitted, but absorbed; while, on the other hand, the retina is transparent. If vision were performed in the retina, says Marriotte, it seems that it should be found wherever the retina is; and since the retina covers the whole nerve, as well as the rest of the bottom of the eye, there appears no reason why there should be no vision in the place of the optic nerve. M. Picquet argued in opposition to Marriotte. He observed, in regard to the fitness of the black colour of the choroides for the action of the rays of light, that the choroid is not universally black; that there are many shades of difference in the human eye; and that it is black, blue, green, yellow, or of a metallic shining surface, in a variety of animals. He conceived that the defect of vision at the insertion of the nerve is occasioned by the blood-vessels of the retina.† He observed, also, that the opacity of the retina is such, as necessarily to obstruct the transmission of the rays of light to the choroid coat. M. De la Hire took part in this controversy. He considered the retina as the organ of sight, although a particular point of it is not susceptible of immediate impressions from outward objects; for, says he, we must not conceive sensation to be conveyed by any other means than by the nerves. But, observing the constitution of the other organ of the senses, he entertained an idea that the retina receives the impression in a secondary way, and through the choroides, as an intermediate organ; that, by the light striking the choroid coat, it is agitated, and communicates the motion to the retina: and we find that through all the organs of the senses, he continues, the nerves are too delicate to be immediately exposed to the naked impressions of external bodies.

* Dr. Smith made the stream of light through the keyhole of a dark chamber fall upon this point of the retina, opposite to the termination of the optic nerve, but he found it quite insensible even to this degree of light. M. Picquet asserts that very luminous objects make a faint impression on the centre of the optic nerve. But Dr. Priestley says, that a candle makes no impression on that part of his eye.

† Against this hypothesis, the size of the insensible spot was urged by Marriotte. Bernouilli calculated that this spot is a circle, the diameter of which is a seventh part of the diameter of the eye, and that the centre is twenty-seven parts of its diameter from the point opposite to the pupil, and a little above the middle.

Another objection to the opinion, that the retina is the seat of sensation, has been lately urged, viz. that the thickness of this coat, together with its transparency, allows of no particular surface for receiving the image; and that its transparency would cause a partial dispersion, which would produce a confusion in vision.*

If these opinions require serious refutation, we have it in the effects of the diseases of the retina, optic nerve, and brain. But the thalami nervorum, the optic nerve, and its expansion into the retina, seem scarcely to have ever occurred to these speculators as worthy of notice in this investigation.

The following appears to me the true account of this matter. The outer or posterior surface of the retina (being that which is towards the newly-discovered membrane) is the proper seat of vision. That it must be a *surface* on which the object is represented, is evident from the consideration of the extreme minuteness of the objects painted there. Now, it is to be considered that at the point where the optic nerve comes through the coats of the eye, there is no posterior surface peculiarly adapted to receive the impression of light; and as well might we expect the optic nerve to be sensible to the impression of light in any point of its extent from the brain to the eye, as at this; for here the inner surface of the retina only is formed: there is no posterior surface upon which the rays can impinge. The doubts regarding the cause of this spot giving no sensation, have arisen from the idea, that the internal surface of the retina, or its substance, felt the impression of the rays of light.

At the same time it is evident, that the choroid coat, and its secretion, is in a most remarkable manner subservient to the retina, as the instrument of vision; for, when the secretion is black, it absorbs the rays; and animals which have such a pigmentum nigrum see best during the full day: again, when the surface is of a shining nature, it repels the rays, and this contributes to strengthen the sensation; and such animals are fitter for seeing in obscure light: nay, further, if the surface of the choroid be coloured, the animal will see objects of that colour the best, because the colour of the choroid depends upon its reflecting more of the coloured ray than of the others of which light is composed.

But as animals see which have no paint on the choroid, (neither such as will absorb, nor such as will strongly reflect the rays,) and which have merely the surface of the choroid with its coloured blood-vessels in contact with the retina; so it is evident, that it is not the deficiency of the choroid coat, nor the want of the black paint at the entrance of the optic nerve, which prevents the sensation, but, really, that there is here no surface formed and organised to receive the impression of the light, the internal surface not being the sensible surface of the retina.

* M. Le Cat thought the pia mater was the sentient part of the nerve. It was, therefore, a kind of confirmation of his opinion to suppose the choroid to be the seat of vision, as he teaches that the choroid coat is a production of the pia mater. He conceived that the retina moderated the impression of light upon the choroid coat, as the cuticle dulls the impression on the papillæ of the tongue.

FURTHER OBSERVATIONS ON THE RETINA.

It has already been observed, that vision is the combined operation of the external organ, nerve, and brain; consequently, the destruction of the function may be produced by disease of the retina, of the optic nerve, or of the brain. Any partial injury, pressure, electricity, or galvanism, influencing the retina, will cause the sensation of light or fire before the eye.* Because here, or in its corresponding part of the brain, is the organ of vision; and no idea but of light is this organ capable of exciting in the mind. Disease in the retina, nerve, or corresponding part of the brain, causing total blindness, while the cornea and humours of the eye remain pellucid, is called AMAUROSIS. It is, in general, to be considered as a paralytic affection. Amaurosis† has been found to follow strokes on the head; concussion and compression of the brain; blood effused within the skull; or tumours passing on the nerve or brain.‡ An amaurosis spasmodica has been enumerated by authors. This kind of blindness has been supposed to arise in consequence of the stricture of the optic nerve by the origins of the recti muscles: as far as I have observed, no action of these muscles can affect the optic nerve before it perforates the coats of the eye. If it were to be attributed to the operation of these muscles, I should rather suppose it to be occasioned by their spasmodic action on the ball of the eye, by which the function of the retina may be disordered; but I think it is more probable that the same irritation which is acting on the motory nerves of the eye, does, in this instance, affect also the optic nerve and retina. However, distention of the coats of the eye, by increased secretion of the humours, destroys the sensibility of the retina. In the hydrophthalmia, there is in the beginning a short-sightedness, so that objects are seen only when near the eye. Thus far we might account for the defect of vision by the alteration of the focus of the cornea and humours; but by-and-by, as the eye enlarges, as it becomes turgid, and the coats more distended, the pupil becomes stationary, and the vision is lost before the aqueous humour has become turbid.§

* Light from pressure on the eye. See Cartesius, cap. ix. lib. de Meteor, and the Ophthalmographia of Briggs, *Cornea*.

† AMAUROSIS; GUTTA SERENA; CATARACTA NIGRA; which last name is from the blackness of the pupil in consequence of the transparency of the lens.

‡ "Ipse vidi bis in puerulis scrophulosis amaurosin, etiam subito ingruentem; secto cadavere inveni glandulam strumosam nervis opticis incumbentem." *Sauvages Nosol.* From many observations we find that tumours and extravasations, which must compress gradually, do yet produce an instantaneous effect.

In Bonetus‖, we have many cases of blindness from abscess in the anterior part of the brain; from fluid on the surface, and in the ventricles; from steatomatous tumours: from coagulum of blood, and from a hydatid pressing on the union of the optic nerves; and, lastly, from a calculus in the optic nerve. For a case of blindness from pressure upon the eye and its displacement, and consequent elongation of the optic nerve, by an encysted tumour in the orbit, with gradual recovery after operations, see *Med. Ob. and Enquir.* vol. iv. p. 371.

§ Luxation, or displacement of the eye, by tumours, causes blindness, by extending the optic nerve or compressing the eye-ball, and consequently the retina.

‖ De Ocul. Affectibus, Ob. 2.

The connection and sympathy betwixt the retina and the viscera of the abdomen is very particular. We have proofs of this in the disorder of the stomach having an immediate effect on the sensibility of the retina. Allied to this, but greater in degree, is the amaurosis, which attacks hysterical women suddenly, with headache and violent pain. From such sympathy of parts arise the amaurosis biliosa, verminosa, intermittens, arthritica, &c. Similar attacks of blindness have been found to alternate with convulsions.*

Commencing cataracts and opacities of the cornea, and of the humours in general, give occasion to spots and obscurities in the vision; but we have at present to consider those only which depend on the state of the nerve. Errors of vision are not easily to be distinguished from those of the imagination proceeding from the brain; error opticus, or hallucinatio, from delirium: one distinction of the former is, that we can correct the deception by the assistance of the other senses, while in the latter, the mind is disturbed.

Old people are often troubled with the appearance of dark irregular spots flying before their eyes. In fever, also, it is very common to see the patient picking the bed-clothes, or catching at the empty air. This proceeds from an appearance of motes or flies passing before the eyes, and is occasioned by an affection of the retina, producing in it a sensation similar to that produced by the impression of images; and what is deficient in the sensation, the imagination supplies; for, although the resemblance betwixt those diseased affections of the retina and the idea conveyed to the brain may be very remote, yet, by that slight resemblance, the idea usually associated with the sensation will be excited in the mind.

M. De la Hire attributed the fixed spots to drops of extravasated blood on the retina, and the flying ones to motes in the aqueous humours†; but we shall show presently, that this apparent motion of the motes before the eyes may be a deception. After turning round upon the heel for some time, objects apparently continue in motion. Dr. Porterfield supposed this to proceed from a mistake with respect to the eye, which, though it be at rest, we conceive to move the contrary way to that in which it moved before; from which mistake, with respect to the motion of the eye, the objects at rest will appear to move the same way the objects are imagined to move, and, consequently, will seem to continue their motion for some time after the eye is at rest. How superior is simple experiment to the most ingenious speculation! Dr. Porterfield is pre-

* The following is an ingenious account of the manner in which this may be produced, though to me it is not satisfactory: — "Non infrequens cæcitas post convulsiones graves et frequentes, sed a nemine quod sciam recte descripta causa; hanc non ab humoris affluxu deduco, ut voluerunt, sed quia in magnis illis per paroxysmas convulsionum partium omnium, et oculorum simul contortionibus in quibus sæpe quoque convulsi, admodumque exerti et inflexi apparent, attracto sic nimium et tenso nervo optico, illis adnato illoque simul contorto et læso, spiritusque visorii transitu impedito, oculos visione privari contingit. atque inde provenire diligente examine et consideratione invenimus." *Platerus Prax.* lib. i. c. 7.

† "Guttula cruoris retinæ insidens et nigricans, omnem lucem intercipiet unde phantasma obscurum vel nigrum; verum si dilutus cruor radios rubros transmittat tunc maculam rubram videbit æger ut omnia trans vitrum inspecta rubra sunt." *Sauvage*, vol. iv. p. 287.

suming in all this, that the eye is at rest when the body is stationary, after turning round rapidly on one foot. But the fact is, that the eyes continue in motion after the body is at rest, but, owing to a disorder in the system of sensation, we are not sensible of it. Dr. Wells, in making an experiment, in which it was necessary to look upon a luminous body, was seized with giddiness; and he found, that the spot on the retina, affected by the great excitement of the luminous body, did not remain stationary, but, when made apparent by looking upon the wall or any plane, was moved in a manner altogether different from what he conceived to be the direction of his eyes. In making the experiment, after looking some time at a candle, and then turning himself round till he became giddy, he afterwards directed his eyes to the middle of a sheet of paper: he saw the dark spot (caused by the former brilliancy of the candle on the retina) take a course over the paper, although he conceived that the position of his eyes remained stationary. He then directed a person to repeat this experiment, and then bade him look stedfastly to him, and keep his eyes fixed; but, instead of being stationary, they were seen to move in the socket; though, of this the person himself was quite insensible.*

From these experiments we may conclude, that spots which seem to move before the eyes are not, on that account, solely to be attributed to opacity of the humours or cornea, since the appearance of motion may be given to those motes, though occasioned by an affection of the nerve; especially, if the unusual sensation be attended with giddiness. Giddiness, however, is not necessary to such sensation: when my eyes are fatigued, and, sitting in my room, I look towards the window, I see before me small lucid circles, which seem to descend in quick succession: upon attending more particularly to my eyes, I find them in perpetual motion; my eye is turned gradually downward, which gives to the spectrum the appearance of descending; but it regains its former elevation with quick and imperceptible motion. During the slow inclination of the eye downward, the motes or little rings seem to descend; but, in lifting the eye again, the motion is so quick, that they are not perceived.†

There is a kind of umbra seen before the eyes which are occasioned by the vessels of the retina. Of this kind is the suffusio reticularis of Sauvages, in which the person sees ramifications which strike across the sphere of vision, and are synchronous with the pulse, showing its

* The author has pursued this subject further, both in a succeeding part of the volume, and in the Phil. Transac. for 1823.

† The following quotation refers to this sensation: — "Æger in magnâ luce constitutus, ut plurimum presbyta, vel oculis nitidissimis gaudens continuo præ oculos observari sibi putat puncta lucida, quæ non huc et illuc volitant, nec a commoto capite agitantur, ut putat La Hire, et ejus in hoc exscriptor Boerhaave; sed constanter si oculus immobilis remaneat, deorsum lentissime delabi videntur; adeoque veluti pluvia aurea præ-oculos eaque densa cernitur; quæ verticaliter semper descendit in quacunque capitis positura, sive erecta, sive lateraliter inclinata; hoc in me ipso expertus per annos, observari in aliis, potissimum illos qui studio nocturno indulserant, et in ægrotante, qui de eo symptomate ad melancholiam fere per multos annos solicitus erat." *Sauvages.* This appearance has been attempted to be explained, upon the supposition of a very sensible state of the retina, which perceives the guttulæ exuding from the pores of the cornea, and which, falling over its surface, gives the appearance of their descending. But it is only felt when the retina is exhausted or disturbed by pressure on the eye-ball. See *Sauvages Suffusio Scintillans et Suff. Danaës.*

dependence on the full and throbbing pulsation of the head. There are also coruscations seen before the eyes in consequence of a blow upon the eye-ball, and accompanying violent headache, vertigo, phrenitis, epilepsy, &c. Whatever forces the blood with great violence to the head, as coughing, vomiting, sneezing, will cause, for the instant, such coruscations, by means of the disturbed circulation through the retina*

We are particularly called upon to attend to the connection betwixt the iris and the retina. In amaurosis, the sensibility of the retina being entirely lost, the pupil is consequently immovable and dilated.† But we must recollect, that if one eye be sound, the pupil of the diseased eye follows, in some degree, the movement of the iris of the sound eye. If one eye be shut, the pupil of the other eye will dilate; if the hand be put over the eye-lids of the shut eye, the pupil will still further dilate.‡

We find several instances of vision indistinct during full day-light, and perfect in the crepusculum. This we have explained by the dilatation of the pupil allowing the rays of light to pass the partial opacity of the lens: it, of course, has no connection with the disease of the retina.

There are also instances of vision being more than naturally obscure in the twilight, which is owing to a degree of insensibility.§ The night-blindness, however, is not to be entirely attributed to a degree of continued insensibility in the nerve. The attacks are irregular, and allied to the intermitting amaurosis. It has been epidemic, and the following cases seem to ally it with the paralytic affections.||

A man, about thirty years old, had, in the spring, a tertian fever, for which he took too small a quantity of bark, so that the returns of it were weakened without being entirely removed; he therefore went into the cold bath, and, after bathing twice, he felt no more of his fever. Three days after his last fit, being then employed on board of a ship in the river, he observed, at sun-setting, that all objects began to look blue, which blueness gradually thickened into a cloud, and not long after he became so blind as hardly to perceive the light of a candle. The next

* This was my opinion, as well as that of other physiologists; but I have proved it to be incorrect. The effect contemplated proceeds from the sudden action of the muscles of the eye-lids.

† There are, however, cases of AMAUROSIS A MYOSI, in which there is a contracted and immovable pupil, and children are born with an insensibility of the organ in which the pupil is not greatly dilated. I would be willing to attribute this peculiarity of the pupil and apparent amaurosis in newly-born children to the remains of the membrana pupillaris.

‡ The sympathy of the iris with the retina I do not conceive to be immediate, but through the intervention of the brain; and the degree of dilatation of the pupil I should hold to depend on the strength of the common sensation of both eyes. By this only can we account for the sensibility of the retina of one eye affecting the iris of the other, or the disturbance of the brain, in comatose diseases, destroying the sympathetic connection betwixt the retina and pupil.

§ Est immanis differentia inter splendorem et activitatem luminis candelæ et lunæ: luminis solaris vis est ad vim luminis candelæ 16 pedis distantis, observante D. Bonguer ut 11,664 ad 1; et ad lumen lunæ in pleni lunio, ut 374,000 ad 1 demonstrante D. Euler, Mem. de l'Acad. de Berlin, an. 1750, pag. 299.; non mirum itaque si vis toties major sufficeret ad succutiendam retinam quam tanto minor non afficiebat. *Sauvages Amblyopia Crepuscularis.*

|| By Dr. Heberden.

morning, about sun-rise, his sight was restored as perfectly as ever. When the next night came on, he lost his sight again in the same manner; and this continued for twelve days and nights. He then came ashore, where the disorder of his eyes gradually abated, and in three days was entirely gone. A month after, he went on board of another ship, and, after three days' stay in it, the night-blindness returned as before, and lasted all the time of his remaining in the ship, which was nine nights. He then left the ship, and his blindness did not return while he was upon land. Some little time afterwards, he went into another ship, in which he continued ten days, during which time the blindness returned only two nights, and never afterwards.

In the August following, he complained of loss of appetite, weakness, shortness of breath, and a cough: he fell away very fast, had frequent shiverings, pains in his loins, dysury, and vomitings; all which complaints increased upon him till the middle of November, when he died. He had formerly been employed in lead-works, and had twice lost the use of his hands, as is usual among the workers in this metal. See Medical Transactions, published by the College of Physicians in London, vol. i. p. 60.

Pye*, servant to a miller, at the 6th mill on the Limehouse wall, about 40 years of age, came to me, October 2d, 1754, for advice and assistance. He told me, that about two months ago, while he was employed in mending some sacks, near the setting of the sun, he was suddenly deprived of *the use of his limbs* and of his sight. At the time he was attacked with this extraordinary disease, he was not only free from any pain in his head or his limbs, but, on the contrary, had a sensation of ease and pleasure: he was, as he expressed himself, as if in a pleasing dose; but perfectly sensible. He was immediately carried to bed, and watched till midnight; at which time he desired those who attended him to leave him, because he was neither sick nor in pain. He continued the whole night totally blind, and without a wink of sleep.

When the day-light of the next morning appeared, his sight returned to him gradually, as the light of the sun increased, till it became as perfect as ever; when he rose from bed, his limbs were restored to their usual strength and usefulness, and himself in perfect health.

But on the evening of the same day, about the setting of the sun, he began to see but obscurely, and his sight gradually departed from him, and he became as blind as on the preceding night; though his limbs continued as well as in perfect health; nor had he, from the first night, any complaint from that quarter.

The next day, with the rising sun, his sight returned; and this has been the almost constant course of his disease for two months past. From the second night the symptoms preceding the darkness were, a slight pain over the eyes, and a noise in his head, which he compared to a squashing of water in his ears.

After near two months continuance of the disease, on September the 29th the patient was able to see all night; on the 30th September, October 1 and 2, he was again blind all night; on the 3d he was able

* Case by Dr. Samuel Pye.

to see; on the 4th he was blind till 12; on the 5th was blind. From this he had no return of his complaint till June 1755; from which time till the third of October, when I again saw him, he had three or four attacks; from the 3d till the 10th he had an attack every evening.—He had at this time a purging. I ordered him an electuary of bark and nutmeg, which succeeded in removing the blindness; but the diarrhœa continued wasting him. On the 20th, delirium came on; on the 21st he became deaf: he died on the 25th, after having suffered from fever, pain in his bowels, and continued diarrhœa; but the defect in his eyes never returned after the 10th. This man had clear bright eyes: when his sight failed him the pupils were enlarged about one third in diameter. Medical Facts and Enquiries, vol. i. p. 111. I could give other cases from my note-book, but these are sufficient.

Boerhaave gives us an example of imperfect vision from a discordance betwixt the contraction of the iris and the excitement of the retina; so that the pupil did not dilate in the proportion to the decay of light.*

When inflammation extends within the eye, or when the retina is excited by sympathy with the ophthalmia of the outer membranes, it may happen that the patient is totally blind during the day, and yet sees on the approach of evening, because, from the sensibility of the retina, the pupil is absolutely shut, but as the light is diminished, the pupil is gradually relaxed, and the obscure light admitted, and this obscure light, from the irritable state of the retina, gives a vivid sensation incomprehensible to the by-standers. Our judgments of the strength of sensations are comparative merely: when we have been accustomed to strong impressions, lesser ones are disregarded. The greater light destroys the capacity of the retina for receiving slighter and more delicate impressions; while, on the other hand, the absence of light reserves to us the power of seeing objects the most faintly illuminated. We are every day becoming more acquainted with the invisible properties of light; and we have frequent experience of darkness being relative, and that which we should call total darkness is very often but a fainter light. One man will see distinctly when another is quite deprived of the power of discerning objects. A man in prison seems to have the light gradually admitted to him; and many animals are in quick pursuit of their prey, while we are groping our way with the assistance of our other senses.

Animals which seek their prey in a light which is darkness to us, have, most probably, a greater degree of sensibility of the retina. But they have also a more conspicuous apparatus in the largeness of their eyes, and the dilatability of their pupil, while the sensibility which this provision gives is often guarded from the light of day by the membrana nictitans, and by an iris capable of great contraction. Their iris possesses also a great power of contraction in narrowing the pupil during the day, as it is capable of dilating during the night, to the whole extent of the cornea. In the human eye, also, the strict sympathy between the iris and retina is a guard to the latter. But it has often happened that, in using optical instruments, the retina has been hurt by the intensity

* In old people there is an obscurity of vision, from a diminished sensibility of the retina; and the iris does not take a quick succession of contraction and dilatation with the change of light.

of the light from the concentrated rays: a lesser degree of this effect we have given us in the following instance* :—

"Being occupied in making an exact meridian, in order to observe the transit of Venus, I rashly directed to the sun, by my right eye, the cross hairs of a small telescope. I had often done the like in my younger days with impunity; but I suffered by it at last, which I mention as a warning to others. I soon observed a remarkable dimness in that eye, and for many weeks, when I was in the dark, or shut my eyes, there appeared before the right eye a lucid spot, which trembled much like the image of the sun seen by reflection from water. This appearance grew fainter and less frequent by degrees, so that now there are seldom any remains of it. But some other very sensible effects of this hurt still remain :—For, first, the sight of the right eye continues to be more dim than that of the left; secondly, the nearest limit of distinct vision is more remote in the right eye than in the other, although, before the time mentioned, they were equal in both these respects, as I had found by many trials; but, thirdly, what I chiefly intend to mention is, that a straight line in some circumstances appears to the right eye to have a curvature in it. Thus when I look upon a music-book, and, shutting my left eye, direct the right to a point of the middle line of the five which compose the staff of music, the middle line appears dim indeed at the point to which the eye is directed, but straight; at the same time the two lines above it and the two below it appear to be bent outwards, and to be more distinct from each other, and from the middle line, than at other parts of the staff to which the eye is not directed. Fourthly, although I have repeated this experiment times innumerable within these sixteen months, I do not find that custom and experience take away this appearance of curvature in straight lines. Lastly, this appearance of curvature is perceptible when I look with the right eye only, but not when I look with both eyes; yet I see better with both eyes together than even with the left eye alone."

Herschel, in making his observations on the sun, found the irritation to proceed from the red rays* (being those of the rays of light which have the property of producing heat in the greatest degree): he found, when he used red glass to intercept the too vivid impression of light on his eyes, that they stopped the light, but produced an insufferable irritation from the degree of heat. But when he used green glass it transmitted more light, and remedied the former inconvenience of an irritation arising from heat. He concluded that, in the darkening glasses for telescopes, the red light of the sun ought to be entirely intercepted. Boerhaave mentions an instance of the retina being injured by the long use of the telescope, and he himself was hurt by a similiar cause. These injuries are owing to the intrusion of light highly concentrated, and over which the pupil has no command; it is a degree of intensity which the organ is not prepared to counteract.

* Viz. by Dr. Reid.

† See a curious intance of red colours producing convulsions in an epileptic patient. *Sandifort Thes.* vol. iii. pag. 314.

OF THE MEMBRANA PUPILLARIS.

The membrana pupillaris is an extremely vascular membrane, which is extended across the pupil of the fœtus. It was discovered by Haller, Albinus, Wachendorf,* and Dr. William Hunter, at the same time, or without correspondence with each other.

Haller†, after injecting, with oil of turpentine and cinnabar, a fœtus of the seventh month, saw through the cornea the vessels of the iris injected, and some ramifications from them produced into the space of the pupil. From conviction that no vessels ramified without an involving membrane, he naturally concluded, that a membrane was drawn across the pupil of the fœtus, though, in this instance, it was about to disappear.

In several other fœtuses of the seventh month he confirmed his first observation ; and, cutting off the cornea, he observed the membrane impelled forward by the humours behind like a little vesicle.

Albinus, in his first book of Academical Annotations, thus describes the way in which he detected this membrane. In the same child, in whom he had filled the vessels of the crystalline lens, he also first observed the membrane which closes the pupil, and in which the vessels were injected that came from the margin of the pupil. Upon looking through the cornea, he could see no distinction of parts, but all seemed vascularity. He conceived, at first, that these were the vessels of the uvea, and that it had quite contracted, and had shut the pupil ; then that they were the vessels of the capsule of the crystalline lens ; but, having cut into the eye, he found it to be this membrane. Dr. Hunter, speaking of this membrane, and of Albinus's claim to the discovery, says, " In justice to this great anatomist, I must declare that I believe this, both because he asserts it, and because I know from the circumstances it was hardly possible he could miss taking notice of it in that child." " I have always observed," he continues, " both in the human body and in the quadruped, that there is a great resemblance to one another in the vessels of the capsula crystallini and of the membrana pupillæ. In an injected fœtus, I always find both nearly in the same state : if one be filled only with the blood that is drove before the injection, so is the other ; if one be filled partly with injection, and partly with blood, the other is in the same condition ; if one by good fortune be finely and minutely filled with injection, the other is so too ; if one be burst by extravasation, the other is commonly in the same state ; and when the fœtus is so near its full time that the one cannot be injected, neither can the other."‡

Dr. Hunter, speaking further of the artery of the crystalline capsule, says, " that it does not terminate at the great circle of that humour. Its small branches pass that circle, and run a very little way on the anterior surface of the crystalline humour before the points of the ciliary

* In Commercio Notico, A. 1740, hebd. 18. as quoted by Haller.
† De novâ tunicâ pupillam fœtus claudente. Oper. minor.
‡ See Medical Commentaries, p. 63. foot-note.

processes ; then they leave the humour and run forwards, supported on a very delicate membrane, to lose themselves in the membrana pupillæ." He continues : " The membrana pupillæ receives two different sets of arteries, one larger, from the iris, and the other much smaller, but very numerous, from the crystalline capsule."

Now I think that every expression in these excerpts confirms the opinion I entertain, that these vessels which are seen filled with red blood, and which take their course through the humours, are subservient merely to the membrana pupillaris.

The first time I observed the membrana pupillaris, was in the eye of a child born at the full time. I had injected the child very minutely with size and vermilion, and the iris was beautifully red and the pupil quite transparent and black, and not obscured by any extravasation of the injection into the aqueous humour : upon very narrowly observing the circle of the iris, I saw distinctly a small injected vessel pass out from the edge of the iris, and, crossing the pupil, divide into two branches, which ran into the opposite margin of the iris. This was the remains of the membrane, but so delicate and so perfectly transparent, that the presence of it was only to be presumed from the vessel which was seen to cross the pupil.

Since that time I have often seen it in the early months, and particularly strong about the seventh month of the fœtus. It is then an opaque and very vascular membrane, and generally it has spots and streaks of of extravasation in it. The vascular structure of this membrane is very particular, and I can assign no other reason for this than that it may be a provision for its rapid absorption. It has evidently two sources of vessels, viz. the vessels of the capsules, and those of the iris ; but whether the arteries come by the one source, and the veins depart by the other, I cannot determine. In one preparation I see the vessels with their trunk in the membrana pupillaris, and the branches sent over the surface of the iris.

The larger and flat venous-like vessels of the membrane are distributed in a beautiful net-work, in the form of the lozenge of a Gothic window. They have a free communication with each other. In their whole course the vessels seem nearly of the same size (which also is like the character of a venous net-work), and they terminate apparently in the margin of the iris.

Haller makes a comparison betwixt this membrane, which closes up the pupil, and that matter which is accumulated in the passage of the ear in the fœtus. But there is no analogy.—As the waters of the amnios might otherwise be in contact with the membrane of the drum of the ear, and injure what necessarily is of a dry and arid nature, this matter accumulated in the ear of the fœtus defends it. But at the time when the membrana pupillaris exists in its full strength and vascularity, no light is admitted into the eye—the fœtus is lying in the womb. Towards the ninth month, the membrane has become transparent, and, if not totally absorbed, it is torn by the first motion of the pupil, and altogether disappears. It can, therefore, have no effect in obscuring the light, and preventing it from exciting in too great a degree the eye of the newly-born child. I offer with some hesitation the following rationale : it is the nature of the iris to contract its circular fibres during the operation of light,

so as to stretch the membrane, and to close or nearly close the pupil; that, on the other hand, the pupil is completely dilated through the operation of the radiated fibres of the iris in darkness:—To the question, then, why it is not dilated during the fœtal state? The answer, I think, may be this:—The iris is not loose in the fœtal state: it is connected and stretched to the middle degree of contraction and dilatation by the membrana pupillaris. Were the iris in a full state of contraction during the life of the fœtus, it could not receive its full nourishment, proper degree of extension, and due powers; but, being preserved stationary and extended, the disposition to contraction, which it must have when the retina is without excitement, is counteracted, until it is about to receive, by the birth of the child, that degree of excitement which is to keep up the balance betwixt the two classes of fibres: those which dilate, and those which contract, the iris.

OF THE HUMOURS OF THE EYE.

OF THE AQUEOUS HUMOUR.

The aqueous humour is perfectly limpid. The use which I have assigned to the aqueous humour explains its nature and the extent of the chamber which contains it; viz. that it distends the cornea, and allows the free motion of the iris: it consequently fills the space between the lens and cornea. The usual description is, that it is lodged in two chambers: the one before the iris, called the anterior chamber of the aqueous humour; and the other behind the iris, called the posterior chamber of the aqueous humour.

This posterior chamber was, at one time, conceived to be of great extent*, and authors spoke of depressing the lens into the posterior chamber of the aqueous humour.† It is found, now, that betwixt the lens and iris there is no space to which we ought to give this name of chamber.

Heister, Morgagni, and M. Petit (médecin) first demonstrated the extreme smallness of the posterior chamber; and, after them, Winslow confirmed the fact, that the iris moved almost in contact with the anterior surface of the lens.

M. Petit gave the clearest proof of the smallness of the posterior chamber, by freezing all the humours of the eye, and dissecting them in their solid state. Without this expedient it was impossible to prove the relative size of the two chambers; for, whenever the cornea was cut, the aqueous fluid escaped, and the lens pushed forward. When the eye was frozen, and then dissected, it was found that the ice, which took the shape and dimensions of the anterior chamber, was much larger than that found in the posterior chamber‡; indeed, the latter was formed of a very thin flake of ice. The thin piece of ice in the posterior chamber

* Viz. by Heister. They were called the first and second chambers by M. Brisseau.

† There certainly appears sufficient room for this in Vesalius and Briggs' plates: these plates have misled many.

‡ See Acad. Roy. des Sciences, 1723. Mem. p. 38.

indicated as much fluid only betwixt the iris and lens as might allow a free motion to the iris. These experiments were instituted in the course of investigating the question of the nature of the cataract.

The conclusion, that the posterior chamber of the aqueous humour contained but one fourth of the whole aqueous humour, was admitted with great difficulty and after much contest. It determined the question, whether the cataract was a membrane or the opaque lens; for, as those who maintained that it was a membrane, said it could not be the lens, because the lens was far distant from the iris, it was necessary for their opponents to prove that the lens was close upon the pupil, and that the posterior chamber of the aqueous humour was very small.

It is agreed that, in the adult, the quantity of the aqueous humour amounts to five grains; in the fœtus it is red, turbid, and weighs about a grain and a half, owing, in part, to the comparatively greater thickness of the cornea.

As it is natural to conceive that the aqueous humour flows from a vascular surface, it is the most generally received opinion, that it is derived from the points of the ciliary processes and surface of the iris. Haller, particularly, and after him Zinn, have thought that the ciliary processes were the secreting bodies; but there is one argument, which, in my mind, determines that these are not the sole secreting parts, viz. that while the membrana pupillaris closes up the communication betwixt the two chambers, I have observed the anterior one to be full of the fluid, which of course must have been supplied from another source than the ciliary processes. I suppose, therefore, that the villous surface of the iris is the proper secreting surface of the aqueous humour.* Zinn observes, that Haller saw the membrana pupillaris distended and bulged forwards by the aqueous humour in the posterior chamber. It is scarcely necessary to say, that this must always take place when the cornea is first opened in demonstrating that membrane, whether there be a watery fluid behind it or not. But I believe I shall be able to prove, that the secretion of the ciliary processes can have little power of filling the posterior chamber, even from the connection of membranes behind the membrana pupillaris in the fœtus. The aqueous fluid is perpetually undergoing the change of secretion and absorption, and this is the reason of its quick renewal when it has been allowed to escape by puncture of the cornea. The ancients were not ignorant of the quick regeneration of this fluid. It was proved to the moderns by a charlatan, Josephus Burrhus. Before the physicians of Amsterdam he punctured the cornea of a dog; then, instilling his liquor under the cornea, he bound up the eye: in a few days he took off the bandage, and showed them the cornea again distended with the aqueous humour. It was soon found that the instilled fluid was of no kind of consequence. Redi and Nuck made many experiments,

* The opinion of Nuck is now out of the question. He thought that he had discovered particular aqueducts, which conveyed the aqueous humours into the anterior part of the eye; but these are found to be nothing more than the short ciliary arteries which pierce the fore part of the sclerotica. M. Mery and Bonhomme (see Zinn, p. 143.) observed, in an adult, the pupil closed with the membrane; and, in this instance, there was scarcely any fluid in the anterior chamber, whilst the posterior was turgid with fluid.

and it was found that the aqueous humour was regenerated in the course of twenty-four hours. It is generated much more quickly than this.

When the disputes regarding the cataract ran high, and when to make new distinctions in the disease was taken as a mark of practical knowledge and of acuteness, there was a kind of cataract attributed to the aqueous humour. When the aqueous humour became turbid, white, and opaque, and obscured the pupil, they were absurd enough to call this a cataract. The turbid state of the aqueous humour is at once distinguishable from the opaque lens, because it obscures the iris as well as the pupil.

Pus is formed in the chambers of the aqueous humour, in consequence of deep inflammation, contusions, &c.; and from the same cause sometimes proceeds a bloody effusion. When the pus has lodged in the anterior chamber of the aqueous humour, it would appear, upon the authority of Galen, that an oculist of his day performed a cure by shaking the patient's head! * It is an operation of oculists to puncture and allow the pus to flow out, and some have even syringed out the pus with water†; but this must have been on the principles of Jos. Burrhus's exhibition; for the natural secretion is here the best diluent. When we recollect the nature of the parts with which the pus lies in contact, we cannot be sanguine in the hope of such an operation saving the eye. Sometimes there remains, after operation on the cornea, or in consequence of ulceration, a continued flow of the aqueous humour; the consequence is a subsiding of the cornea ‡: it becomes corrugated, opaque, and, from the contact of the iris, apt to adhere to the iris. In consequence of this suppuration, there sometimes follows an absolute obstruction of the pupil, from the coalescing and adhesion of the edges of the iris.§

THE VITREOUS HUMOUR.

The vitreous humour, as already explained, occupies almost entirely the great ball of the eye. It is consequently beyond the lens, and keeps it at the requisite distance, to cause the rays from objects to concentrate and impinge upon the retina. The vitreous humour is considerably denser than the aqueous humour.|| Its involving membrane is called membrana hyoloides sive vitrea.¶ The peculiar appearance of this humour, its glairy-like consistence, is not owing to its density, but to the manner in which it is contained in its membranes. From being con-

* Mouchart says, he has often seen the oculist Woolhouse repeat this cure, by shaking his patient's head over the side of the bed. He attributed the cure to the falling of the pus into the posterior chamber, which, he supposes, has parts more capable of absorbing it.

† They were at variance regarding the place at which to puncture for this discharge:—Some did it behind the iris; there we know there is a crowd of vessels: the best place is the lower edge of the cornea before the iris. It seems to have been no uncommon accident, in this operation, to find the lens protruded through the pupil. The reason of this has been already explained.

‡ Rhytidosis, seu subsidentia et corrugatio corneæ.

§ Viz. Synisesis. There occasionally occurs congenital imperforation of the pupil.

|| It is, according to Dr. Monro, in the proportion of 1016 to 1000.

¶ Ophthalmographia, authore G. Briggs, 1676. Cantab.

tained in a cellular structure of perfectly pellucid membranes, it has the adhesion and consistence of the white of an egg. This membranous structure of the vitreous humour has been demonstrated by acids and by freezing. When frozen, it was found to consist of pieces of ice connected by strong membranes, which separated with difficulty, and showed their torn fragments; and M. Demours lifted the transparent membranes with the point of a needle. Although the vitreous humour appears to be gelatinous it is not so in reality; and, when it is taken from the coats of the eye, it retains the shape for a time, but gradually subsides by the fluid exuding from the membranes, and this is accelerated by puncturing it.

OF THE CRYSTALLINE LENS.

The crystalline humour is a small body, of the shape of an optician's lens, of great power. It is of perfect transparency, and of density much greater than the vitreous humour. Its density to that of the vitreous humour is calculated to be as 1114 to 1016. But the crystalline is not of uniform density, for the centre forms a denser nucleus, surrounded by concentric layers, successively diminishing in density to the surface, where there is the liquor Morgagni surrounding the solid substance and contained within the capsule.

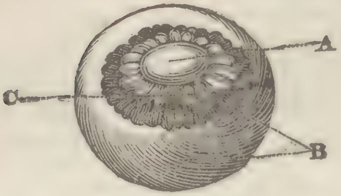
The form of the crystalline is that of a compressed sphere, the anterior surface being more compressed or flatter, though, in a degree, convex. According to Petit, the anterior surface is the segment of a sphere whose diameter is 7, 8, or even 9 lines. The posterior surface is a sphere of 4 or 5, or 5½ lines in diameter. As I have said, the internal structure of the lens is quite peculiar, and resembles neither the vitreous nor the aqueous humour. By maceration it splits into lamellæ, and at the same time bursts up into equal parts, so that there is first a stellated-like fissure, and then it separates into pretty regular divisions. After maceration in acids, the lens can be frittered out into minute shreds and fibres.*

From its form, density, and central nucleus, it has great power of converging the rays of light; and, in an eye properly constituted, it concentrates them accurately to the surface of the retina. For this reason it is placed before the vitreous humour, and socketed in its anterior part. It is contained in a capsular membrane, the *tunica aranea* improperly called †, which membrane is continued from, or connected with, the membranes of the vitreous humour; but this is a subject which requires a more particular investigation.

* See further of the muscularity of the lens.

† Ophthalmographia.

OF THE CAPSULE OF THE LENS AND VITREOUS HUMOUR.



Here we have the appearance of the Petitian canal blown up; A is the lens, B the vitreous humour, C the Petitian canal. It is not found full of any fluid, it is only the laminæ of membrane inflated, and it is best demonstrated when the eye is slightly putrid by cutting off the cornea, and with it a small circular portion of the sclerotica, and taking with these the iris also, when the lens presents itself seated firmly in its capsule on the vitreous humour. Now, laying back the ciliary processes, we make a fine puncture with a lancet by the side of the lens, and then blow gently into it with the blow-pipe.

Every anatomist acknowledges the existence of the Petitian canal, and a distinct capsule to the lens is also pretty generally allowed. But many deny that the vitreous membrane has two plates, without observing that the existence of the Petitian canal is a proof of the splitting of the membrana vitrea, on the fore part at least. Some believe that the vitreous membrane splits and involves the lens, and forms its capsule; but the difficulty, on this supposition, is still to account for the formation of the canal which surrounds the lens; for, as the fluids on the surface of the lens and within its capsule have not admission to the canal, the canal must be distinct; and, indeed, sometimes we blow up the circular canal, and sometimes, by a wrong puncture, the capsule of the lens itself; but not both at once.

Seeing, then, that these cavities are distinct, some anatomists have admitted that the membrana vitrea is double; that the lens has its proper capsule; and that the lamina of the vitreous membrane, coming near the margin of the lens, splits and involves it in a second coat. Others have supposed the anterior layer of the vitreous humour does not pass over the anterior surface of the proper capsule of the lens, but only adheres to the edge of the capsule of the lens, and forms the Petitian canal. There are yet others who have described the membrana vasculosa of the retina, as forming the capsule of the lens. This is one of those species of anatomy which provokes us to continued research, and mortifies us with disappointment. If this piece of anatomy, when investigated in the eye of an adult, is difficult to be understood, it is infinitely more com-

plicated in the eye of the fœtus; and, for my own part, I cannot reconcile my experience with any former opinion.

I conceive that it is the membrana vasculosa tunicæ retinæ, or membrana vasculosa Ruyschii, which forms the vascular capsule of the lens in the fœtus, and also the canal of Petit in the adult. The crystalline lens has, in the first place, its proper capsule, which surrounds it on all sides: again, the transparent web of membrane that is continued onward from that part of the retina which has upon it the pulpy and nervous expansion, splits when it approaches the margin of the lens. One lamina goes round behind the lens, and the other passes a little before it, forms an adhesion to the capsule of the lens, and is then reflected off to the points of the ciliary processes and to the membrana pupillaris of the fœtus.* Betwixt these split laminæ of the continued membrane of the retina, the canal which surrounds the lens is formed. The membrana vitrea is simply reflected over the back of the lens, and has no part in forming the Petitian canal. Where the retina advances forward upon the ciliary processes, it forms an adhesion, beyond which the medullary part is not continued; but the membrana vasculosa passing onward, as I have described, embraces the lens, and the lamina, which passes behind the lens and before the vitreous humour, receives and conveys the artery of the capsule; on the fore part of the lens the anterior lamina only touches the capsule of the lens, adheres, and is then reflected off to form the membrana pupillaris.

In this account I am supported by the most careful investigation, and by the simplicity of this system of vessels; for it will be observed, that it is on the membrana vasculosa alone, that the vessels carrying red blood in the fœtus are supported, and that it shows throughout the same character for vascularity. Again, I think it probable that this membrane which passes before the lens, viz. the membrana pupillaris, and that which passes behind the lens, forming the vascular capsule of the lens, disappear at the same time; or, if this posterior and vascular membrane which passes behind the lens is not totally absorbed, it becomes thin, loses its vessels, and is more intimately united to the membrana vitrea.

ACTION OF THE LENS ON THE RAYS OF LIGHT.

Before leaving this interesting subject, we must endeavour to show the application of these anatomical facts to the function of the lens. When we look upon a magnifying-glass, and see objects through it, we at the same time see the surfaces: that implies that the rays of light, striking these surfaces, are in part reflected, and in part refracted. But if we put the magnifying-glass into water, we no longer see the surfaces; and yet we see through the glass. The reason is this: when a

* In the fœtus, as far as I have observed, the proper capsule of the lens and the membrana pupillaris lie in contact, but they do not adhere; and, while the membrana pupillaris is perfectly red with injection, there is none to be seen on the fore part of the capsule. There is, indeed, no part of that surface which is afterwards to secrete the aqueous humour, which could secrete that fluid, betwixt the surface of the lens and membrana pupillaris; so complete is the adhesion of the adventitious and vascular tunic of the lens to the membrana pupillaris.

ray of light passes from one medium into another, it has a disposition to reflection, in proportion to the difference of density; so that the ray passing through air is reflected from the surface of the glass: passing through water it is not reflected, but refracted, entering through the glass. In the same manner, if the surface of the lens had been exposed to air, or if the exterior surface of the lens had been as dense as its interior nucleus, we should have seen that surface on looking into the eye; that is to say, the rays of light would have been reflected in part, instead of all entering by refraction.

From such views we see why the lens consists of concentric layers, increasing in density inwards, and why its exterior surface is surrounded with the liquor Morgagni. We perceive also the advantage of the cornea being moistened; for the lacrymal secretion has the same influence on the light in entering the cornea that the liquor Morgagni has on the rays entering the lens. The reader will perceive that this effect of the gradual succession of density is different from the effect attributed by Mr. Ramsden, and in addition to it. He observed that the *dispersion* of the refracted rays, producing the coloured rays, was to be observed only where there was a sudden density interposed in the course of the ray; and therefore that the gradual variation of the lens would prevent such dispersion.*

On the whole, therefore, we must conclude that this curious structure of the lens gives an image both more intense and truer in its colours than would be produced otherwise.

OF THE DISTRIBUTION OF THE CENTRAL ARTERY AND VEIN OF THE RETINA.

I am the more anxious to give the accurate distribution of these vessels, that Walter's account of them has tended much to derange that simple and natural view of this system which observation authorises us to take.

The arteria centralis retinæ arises from the ophthalmic artery.† Sometimes it is derived from the ciliary arteries before they enter the coats of the eye, and often there is more than one branch entering the optic nerve.‡ Arising from this source, there are many branches which are distributed to the retina, while a branch passes onward from the lamina cribrosa, through the vitreous humour, to the capsule of the lens. This vessel does not pass exactly in the centre of the vitreous humour, but to one side of the axis of the eye. When it arrives near the capsule of the lens, it divides into three or four branches, which, reaching the capsule, spread beautifully on the back part of it.§

* It is affirmed by Dr. Young, on Experiments, that the dispersive power of the eye is one third of that of crown-glass. He suggests that this effect may be owing to the aqueous humour. *Trans. Roy. Soc.* for Nov. 1800.

† See Haller, Fascic. vii. tab. vi. fig. 2. 4. 7.

‡ Haller, F. vii. p. 42.

§ Walter (de venis oculi) says, the arteria centralis retinæ, having perforated the membrana hyoloidea, passes through the middle of the vitreous humour, and scatters some twigs on the small cells of the vitreous humour. It does not, he says, run through the vitreous humour in a straight line from behind forward, nor does it divide into a

The BRANCHES of the arteria centralis retinæ, which are distributed in the retina, are subservient to its support, and are consequently as visible in the adult as in the fœtus; and, where the membrane of the retina has been described as adhering to the point of the ciliary body, these vessels of the retina unite to or inosculate with the vessels of the ciliary processes.

Walter objects to the description of the arteria centralis retinæ given by Haller and others: he says, decidedly, that there are no arteries distributed to the retina, and that anatomists have deceived themselves in supposing those vessels which ramify on the retina to be arteries, when, in reality, they are veins; he conceives, that the free return of the injection from the extremities of the arteries into the veins has misled them.

I am at a loss to conceive what notions Professor Walter can have entertained regarding this vein distributed in the retina, without an accompanying artery. It is a supposition contrary to the general frame of the economy, and I would oppose to it, with confidence, my own experience; since, in the ox and other animals, I have seen the veins of the retina turged with blood, and exceedingly distinct; yet, when I injected the trunk of the artery at the root of the optic nerve, I found a set of vessels injected on the surface of the retina quite different from the turgid veins, and which could be no other than the arteries distributed to the retina. I must conclude that there is no peculiarity in the distribution of vessels in the tunica vasculosa retinæ.

We frequently observe that the trunks of veins and arteries, destined to the same final distribution, take a different course; but, in their final distribution, I know no instance in which they do not ramify with parallel branches interwoven with each other.

The VENA CENTRALIS RETINÆ, as it is described by Haller, is sometimes a branch of the ophthalmica cerebralis, but often it rises from the cavernous sinus, amongst the origins of the external and inferior recti muscles of the eye: after giving off many small twigs to the periosteum and fat of the orbit, it passes obliquely from behind, forward, and inward, perforates the sheath of the optic nerve, and, after supplying the sheath, dips into the surface of the nerve.—It is now the comes arteriæ centralis retinæ. It enters through the cribriform plate of the optic nerve, and spreading generally in large and remarkable branches on the retina, these make free inosculations with each other, and finally inosculate with the veins of the ciliary processes.

Whether a branch of the vena centralis retinæ is sent off to accompany the branch of the artery which takes its course through the vitreous humour, I have not been able to determine.

OF THE VASCULARITY OF THE PELLUCID MEMBRANES.

IF we cut through the sclerotic and choroid coat, round the optic nerve as it enters the eye, and afterwards cut up the outer coats towards

great number of branches in the posterior part of the capsule of the lens, like radii from a centre, as Zinn has described. He asserts that the lens receives its vessels from the investiture of the membrana hyoloidea, and that they run back from the edge of the lens towards the posterior convexity.

the cornea, the humours fall out from these coats, and will remain suspended in a fluid, hanging by the optic nerve, and closely embraced by the retina: we have now to review these parts taken collectively, independent of the outward and proper coats, and, as I have classed them, as constituting the internal globe of the eye.

The first peculiarity which strikes us here is the perfect transparency of all the parts within the embrace of the retina. As there are, in the adult and healthy eye, no vessels to be seen in the transparent membrane and humours, it becomes a question whether Nature has provided for the support and nourishment of those parts by other means than the common circulation of red blood through vessels? Now, I am inclined to think, that there is no such circulation through them; and I believe that this would be much more generally allowed, were there not something like a proof remaining in men's minds that these humours and tunics were supplied with red blood in the fœtus; whence they deduce the natural consequence that, in the adult state, these vessels are only shrunk so as to convey only colourless fluids. I have, therefore, to give my reasons why I think that these vessels of the fœtus are not subservient to the humours; and I think I shall prove that, when they have once disappeared, they are no longer pervious vessels; that, though those parts which they are supposed to supply should become inflamed and vascular in the adult, these vessels which were apparent in the fœtus do not become enlarged; that they do not administer in any way to inflammation and disease, but that a new source is given, and that vessels are formed which were at no former period discernible.

Why should there be red blood transmitted to the pellucid membranes and humours of the fœtus? Why is not that state of circulation, which nourishes and supports the parts in the adult state, sufficient for their growth and the progress to perfection which they undergo in the fœtus? Why is the capsule of the lens only crowded with vessels carrying red blood, while the proof of vessels passing to the cells of the vitreous coat stands upon some very rare and vague assertions, and such as can be naturally explained by the appearance of those vessels which merely pass through the vitreous humour for a different destination?

I believe this is a view which has been little attended to; but, upon the most minute enquiry, and upon examining the preparations of the vascularity of the eye of the fœtus, I can see no vessels passing into the humours and carrying red blood, which are not finally distributed to the membrana pupillaris. When we lay open the eye of a fœtus, after a very minute and successful injection, we see vessels, which all proceed from the centre of the optic nerve, passing through the vitreous humour to the back of the capsule of the lens, viz. the branches of the arteria centralis retinæ. This artery divides very often into many branches before it arrives at the capsule of the lens: now, if these be filled with blood, or but partially injected, they have the appearance of being branches distributed to the vitreous humour, and not to the lens. This appearance is still more apt to deceive us when the lens is separated from the vitreous humour, and when the vitreous humour is otherwise disturbed, for then the vessels shrink and seem to terminate in the midst of the vitreous humour. When the injection is perfect there is no such appearance.

On the back of the lens we see a profusion of vessels; but I think I may positively say that these vessels do not penetrate to the lens itself, but are merely on the capsule, and that, having made the circuit of the lens, they terminate in the membrana pupillaris and ciliary body. I can observe no villi on the inner surface of the capsule of the lens, nor any appearance of its being a secreting surface, to lead me to suppose that these vessels secrete the lens, as Walter supposes they do; nor, after the most successful injection of the capsule of the lens and of the coats of the eye in general, can I observe the slightest stain of colour in the pellucid state of the lens, nor betwixt its white fibres when it becomes opaque. Nor have I observed, at any time, a single branch of these vessels, which are so profuse on the back of the lens, distributed to the anterior part of the capsule; on the contrary, they all terminate abruptly at that line, a little forward from the utmost verge of the lens, where they are united to the vessels of the membrana pupillaris and ciliary processes. Were these vessels of the capsule provided for the secretion of the lens, or were those vessels the trunks of lesser branches, which pierce into the substance of the lens, they would appear also on the fore part of the capsule.

If I am accurate in these observations, we are authorised to deduce this conclusion:—that these vessels which we see running through the vitreous humour and capsule of the lens, and which are sometimes seen filled with red blood or injected with size and vermilion, are not the vessels of the humours, but vessels in their passage to the membrana pupillaris, and that they disappear totally when that membrane is absorbed. They are injected when the membrana pupillaris is injected: they are more difficult to fill when that membrane is becoming pellucid and tender towards the latter period of gestation; and with the annihilation of the membrane follows the disappearance of the vessels carrying red blood through the transparent humour of the eye.

In confirmation of the total annihilation of these central vessels of the vitreous humour, I have found that, when disease comes upon the lens of the adult, the vessels, which are apparent in consequence of inflammation, do not proceed through the old tract from the centre of the optic nerve and through the vitreous humour to the lens, but that they come from the extremity of the retina and laterally, and thence spread over the back of the lens.

An eye, which I had lately an opportunity of examining, confirmed me in this opinion. I assisted my brother in an operation on the eye, in which, the anterior part being diseased, it was cut away. I had soon an opportunity of retiring and examining the parts with Dr. Monro. I observed then an opaque spot on the posterior surface of the lens, which was indeed in the capsule, and to this spot there came vessels over the margin of the lens from the extremities of the vessels of the retina; but in the vitreous humour there were no vessels to be seen, nor any branches passing into the lens obliquely from behind, as they do in the fœtus.

SOME SURGICAL OBSERVATIONS CONNECTED WITH THE ANATOMY OF THE HUMOURS.

I have already mentioned, as the principle of the operation of extracting the lens, that the simple action of the muscles surrounding the eye-ball is sufficient to protrude the lens, if the incision of the cornea be of proper dimensions relative to the size of the lens. No doubt, if there have been thickening inflammation, and perhaps preternatural adhesions of the membranes surrounding the lens, the operation will necessarily become more complicated; the lens will not glide at once over the cheek when the incison of the cornea is completed. But, still, I think we are not to allow ourselves to consider it as a step of the operation, in any circumstances, that the ball of the eye is to be pressed; because, in that case, the membranes of the lens give way suddenly, and part of vitreous humour unavoidably is protruded with it, or the edge of the lens is turned obliquely to the pupil, and the vitreous humour escapes by the side of it. It is better to destroy the adhesions with the instrument, and to scratch the capsule of the lens so that it may burst: whence it is evident that it is necessary, in order to insure the correct performance of the operation of extraction, that the lens should press equally forward on the pupil, and that the pupil should be allowed to dilate. From this it appears how loose the ideas of those are who can speak of trying first to couch, and, if that is not found to succeed, then to perform the operation of extraction. I conceive the attempt with the needle to preclude the operation of extracting, for these reasons:—An unsuccessful attempt to depress will, in general, be a laboured and reiterated motion of the point of the needle, which must occasion inflammation and an adhesion firmer than is natural. Again, in couching, the lens is removed from the axis of the eye so far only that, in the case of the extracting being attempted, it no longer equally opposes itself to the pupil, the consequence of which must be the escape of the vitreous humour and the detention of the lens.

In regard to the place at which the couching-needle is to be introduced, we may observe, that we are directed by the older surgeons to pierce the sclerotic coat very near to the edge of the cornea, because they were afraid of hurting the lens with the needle. The idea then entertained was, that the cataract was a membrane hung behind the pupil and before the lens. The older surgeons had the idea that the needle entered before the lens, and passed at once into the aqueous humour. We are to disregard these injunctions of surgeons who directed the needle to be introduced with the idea of avoiding the lens; for, while their notions regarding the disease were erroneous, their rules of operating could not be correct: accordingly, we find them differing in their directions as to the place of piercing the cornea; some directing us to pierce it at the distance of one line from the edge of the cornea, others at the distance of four lines and a half.

Now that we know the place of the cataract, and know also that it is the opaque lens, we can be at no loss to introduce the needle correctly. If, says M. Petit, we pierce the sclerotic coat one line from the edge of the cornea, we pierce the tunica conjunctiva, sclerotica, choroid, vitreous

humour, and ciliary processes before the needle enters the cataract. In this puncture, we wound the most vascular part, and, indeed, every delicate part of the eye; for even in this most anterior course the retina is equally lacerated with the others.* But if we pierce the sclerotic coat, three lines from the edge of the cornea, we avoid the ciliary ligament and body, and processes; and by directing it a little forward, in a line towards the opposite margin of the iris, we shall find the point of the needle advancing through the opaque lens; for, although the lens be so opaque as to prevent the light from striking the retina, it is so far transparent, in general, that the needle is distinctly seen entering its substance, and can be then directed, so as to transfix the cataract without hurting the iris.

We have seen that there is no posterior chamber of the aqueous humour fit to contain the depressed crystalline lens. The belief, which even some modern surgeons have entertained, of the possibility of depressing the lens into the aqueous humour, is a remnant of those inaccurate notions respecting the size of the posterior chamber of the aqueous humour, and the place of the lens, which have long been corrected. With this, also, I think ought to have been forgotten, the idea of the rising of the lens after it has been depressed by the cataract floating in the humours.—The fact, I am confident, is this: when, after transfixing the cataract, we endeavour to dislodge it by depressing the point of the needle, we separate the adhesion between the humours and the points of the ciliary processes; we do not, however, unsocket the lens from the fore part of the vitreous humour, but, when the lens descends with the point of the needle from before the pupil, the vitreous humour revolves with it; the consequence of which is, that when the needle is withdrawn, the lens rolls round with the vitreous humour: but as the lens only is opaque, as its firm connection with the vitreous humour, and even the rolling of the vitreous humour itself cannot be seen, this rolling of the lens appears to be the consequence merely of its own buoyancy in the aqueous humour. This adhesion of the lens to the vitreous humour I have been sensible of during its depression, from the elastic nature of the resistance which I felt. When the lens parts from its socket in the vitreous humour, and when it is depressed with such a turn of the needle as puts it under the anterior part of the vitreous humour, it cannot rise again; there is no motion of the eye which can replace it; there is no aqueous fluid, in which, if it were of less specific gravity, it could rise: it lies under, and, in part, imbedded in the vitreous humour. Another idea is, that it rises with the needle; but no one, who understands what is to be done in the operation of the needle, will raise it again opposite to the pupil after the lens is depressed: it ought to be withdrawn without again elevating the point. But what has always appeared to me as the most unaccountable cause that can be assigned for the rising of the cataract is the action of the muscles of the eye.† It has been explained how the lens is protruded by the action of the muscles when the cornea

* In our most modern system of surgery, we are directed to enter the needle one tenth of an inch. To my certain knowledge, not only the ciliary body has been injured by this direction, but even the root of the iris has been seen to be pushed forward on the point of the needle.

† See Mr. Benjamin Bell's *System of Surgery*.

is cut and the aqueous humour let out; for then the uniform resistance of the eye is broken, and there is a motion of the humours towards the breach, and the lens, lying behind the pupil, is the first part to be protruded forward; but when it lies under the anterior part of the vitreous humour (and there it must lie if it is at all displaced), or in whatever situation it happens to be, from that it cannot be moved by the action of the recti muscles; for they embrace the eye on every side, and their action operates uniformly, so that they cannot affect a body immersed in the midst of the humours. For the same reason that we should decline the operation of extracting, after attempts have been made to depress with the needle, I should refuse when the pupil is rugged and irregular, because the disease may be more extensive than it appears to be. Thus cataracts brought on by falls, or blows, or punctures of the eye, are less favourable, as there is danger of the inflammation having gone deep, and having affected the other humours in a way which cannot be known, since the opaque lens is betwixt us and them.

A frequent cause of the failure of the operation of depression is the displacement of the lens backwards; for, when it seems to have gone down with the needle, it has slipped from under it and started backward. In this case the pupil appears clear, but the patient gains little advantage; for the cataract, though removed from the pupil, is still in the situation to obstruct the light.

OF THE EYE-LIDS, OF THEIR GLANDS, AND OF THE COURSE OF THE TEARS.

Having completed the description of the eye, as the organ of vision, we have now to attend to its connections, its adventitious membranes, the glands of the eye-lids, and the course of the tears. It is plainly necessary that the eye should not be loose in the socket; but that in its rolling motion it should still be attached; and that, although the delicate anterior surface must be exposed, the internal parts of the socket should be defended from the intrusion of extraneous bodies. This is accomplished by the tunica conjunctiva.

The TUNICA CONJUNCTIVA, or ADNATA, is the inflection of the common skin of the eye-lids. It goes a little back into the orbit, and is again reflected, so as to come forward and cover the fore part of the eye-ball. Here it is pellucid, and the white coat of the eye shines through it. It covers the cornea also; and here it is perfectly transparent, loses its character of vascularity, and assimilated to the nature of the cornea. As this coat is a continuation of the common integuments, it is, like them, vascular and liable to inflammation. The tunica conjunctiva is the most common seat of ophthalmia. In the commencing inflammation we see the vessels turgid or blood-shot; by-and-by they elongate towards the surface of the cornea; the patient complains of dimness; the dimness becomes apparent to the surgeon; spots of opacity then form in the cornea; and the vessels of the conjunctiva are seen taking their course over the turbid surface of the cornea. In this

stage of the inflammation, by cutting the turgid vessels of the conjunctiva, we interrupt the source of blood for a time, and procure a small evacuation ; but these vessels soon coalesce again, and the flow of blood is renewed. A variety of appearances are produced by this process of inflammation, and these have appropriate names.

The TUNICA ALBUGINEA is the thin tendinous coat formed by the insertion of the recti muscles, which expand over the anterior part of the eye. I would admit this into the enumeration of the coats of the eye, merely to prevent confusion of names, and to make intelligible the descriptions of some of the older writers. It is not properly a coat. Where the conjunctiva covers the anterior part of the eye, the white sclerotic coat is seen under it ; and, in consequence of this, the tunica conjunctiva is sometimes called albuginea.

A very material part of the structure of the eye still remains to be described—an apparatus by which the surface of the eye is preserved from injury, kept moist, and perfectly transparent.

The EYE-LIDS are composed of the common integuments, with this difference only, that they have a cartilaginous margin to give them shape, and muscular fibres, in the duplicature of their membrane, to give them motion. A small semilunar cartilage, which lies like a hoop in their edge, keeps them of a regular figure, and so as to close neatly over the eye. This cartilage having a triangular edge, and the base of the angle forming the flat surface of the margin of the eye-lid, they meet with the most perfect accuracy. Either end of this hoop-like cartilage is connected with the periosteum at the corners of the eye, so as to move with its fellow as upon a hinge. This cartilage of the eye-lid is called TARSUS.

The MEIBOMEAN GLANDS.—These are very elegant little glands which lie under the inner membrane of the eye-lids. About twenty or thirty ducts of these glands open upon the tarsus of each eye-lid. These ducts run up under the vascular membrane of the inside of the eye-lids ; and minute glandular follicles, to the amount of about twenty, are attached to each of these ducts. These glands exude a white albuminous matter, which defends the edge of the eye-lid from the acrid tears, and closes them more accurately by its unctuosity. This matter is soluble in the tears.* The vascularity of the inner surface of the eye-lid is subservient to these glands ; for the vessels forming their ramifications round the little glands secrete the matter into them. This is the seat of the ophthalmia tarsi ; and, following this inflammation, the edges of the eye-lids, and the mouths of the ducts, are sometimes eroded with little ulcers. These ducts are the seat of the stye. This is an inflammation and closing up of the mouth of one of the ducts, which then swells up into a little hard granule in the edge of the eye-lid, accompanied with inflammation of its cyst or surrounding membrane.

OF THE SECRETION AND COURSE OF THE TEARS.

The LACHRYMAL GLAND is seated in the upper and outer part of the orbit, and behind the superciliary ridge of the frontal bone. It is of a

* Majendie.

flattened form, and is depressed into a hollow of the bone. Several ducts from this gland open upon the inner surface of the upper eye-lid. By the reflection of the membrana conjunctiva from the eye-lid over the surface of the eye-ball, dust and motes are prevented from getting behind the eye-ball; and when they have got under the eye-lids, the extreme sensibility of the tunica conjunctiva excites the lachrymal gland, and the orbicular muscle of the eye-lids, (which, by its pressure, accelerates the flow of the tears,) and the dust or motes are washed out. The puncta for absorbing the tears and conveying them into the nose being at the inner angle or canthus of the eye-lids, we see the intention of the ducts of the lachrymal gland opening on the inside of the upper eye-lid towards the outer angle; for, by this means, the tears are spread over all the surface of the eye-ball, by the motion of the eye-lids, before they decline into the puncta. But the tears do not flow only when the gland is excited by dust; their secretion is perpetual, and, together with the motion of the eye-lids, they continually moisten the surface of the eye-ball. Even during sleep it is supposed they continue to flow: and here we may admire a provision for their conveyance towards the inner canthus, in the inclination of the tarsus to each other; for the eye-lids meet only on the outer edge of the broad surface formed by the tarsus, the consequence of which is, that a kind of gutter is left in the angle by the inner edges of the tarsus not meeting, which permits the tears from the ducts of the lachrymal gland to flow towards the puncta lachrymalia when the eye-lids are shut.

The puncta lachrymalia are the mouths of two ducts which form the beginning of a canal for drawing off the tears from the eye into the nose. These puncta are placed at the inner canthus of the eye, one on the termination of the tarsus of the upper eye-lid near the nose, and the other at the corresponding extremity of the lower eye-lid: they are surrounded by a rigid substance; and their open mouths absorb by capillary attraction. These canals lead the tears into the lachrymal sac, and thence the tears pass into the nose.

The caruncula lachrymalis is that little body like the granulation of a wound which lies in the inner angle formed by the two eye-lids. Very small hairs are seen to sprout from it, and some small sebaceous follicles open upon its surface. Connected with the caruncula lachrymalis is the membrana or valvula semilunaris. This is a fold or duplicature of the adnata, which appears like a distinct vascular membrane. It is drawn from under the caruncula lachrymalis, when the eye-ball is directed outward, so as then to appear like a web spread over the white of the eye near the inner canthus. By directing the eye towards the nose, this membrane is again accumulated about the caruncula. Of this more presently.

The lachrymal sac and duct lie in the os unguis or os lachrymale. This sacculus is a bag of an oblong or oval figure: it is sunk into the fossa of the os unguis, and defended by the frontal process of the superior maxillary bone; and it is covered by the ligamentous connection of the orbicularis muscle. This sac is the dilated upper end of the nasal duct; and into it the two canaliculi lachrymales (the extremities of which are the before-mentioned puncta) open as distinct tubes.

Two coats are described as forming the lachrymal sac: a nervous,

white, external coat; and a vascular, pulpy, pituitary membrane. This sac, diminishing towards the lower part, and being received into the complete canal of the bone, becomes the nasal duct. Taking a course downward and backward, it opens into the nose under the inferior spongy bone. The lachrymal sac and duct are by some said to be muscular, which it is conceived is necessary to enable them to convey the tears into the nose; or, it may be, that they act like a syphon, the duct reaching down into the nose, being like the long leg of the syphon, and drawing the tears in at the openings of the puncta.

The lachrymal sac and duct are very frequently diseased and obstructed. For example, after small-pox, syphilis, or in scrophulous constitutions, the inner membrane of the sac being of the nature of the pituitary membrane of the nose, inflames, swells, and adheres. The consequences of this are, first, a swelling of the lachrymal sac in the inner angle of the eye, and a watery or weeping eye: upon pressing the tumour, the tears, mixed with mucus, are forced back through the puncta; by-and-by the sac inflames and suppurates; matter is discharged by pressure of the sac; and, lastly, it is eroded and bursts out, discharging the tears and matter on the cheek. This is the complete character of the fistula lachrymalis. While the sac bursts outwardly, it often does further mischief within, by making carious the thin lamina of bone in which it lies.

MOTIONS OF THE EYE-BALL AND EYE-LIDS.

We do not reflect on those actions of our frame which are most admirable in themselves, which minister continually to our necessities, and perfect the exercise of our organs, until we be deprived of them: like unnatural children, unconscious or unmindful of indulgence, we feel only the loss of benefits. "With much compassion," says the religious philosopher, "as well as astonishment at the goodness of our loving Creator, have I considered the sad state of a certain gentleman, who, as to the rest, was in pretty good health, but only wanted the use of these two little muscles that serve to lift up the eye-lids, and so had almost lost the use of his sight, being forced, as long as this defect lasted, to shove up his eye-lids with his own hands!"*

Two objects are attained through the motion of the eye-ball. First, the control and direction of the eye to objects; secondly, the preservation of the organ itself, either by withdrawing the surface from injury, or by the removal of what is offensive to it. Without keeping this distinction before us, we shall not easily discover the uses of the parts.

There is a motion of the eye-ball which, from its rapidity, has escaped observation. At the instant in which the eye-lids are closed, the eye-ball makes a movement which raises the cornea under the upper eye-lid.

If we fix one eye upon an object, and close the other eye with the finger in such a manner as to feel the convexity of the cornea through the eye-lid, when we shut the eye that is open, we shall feel that the cornea of the other eye is instantly elevated; and that it thus rises and falls in

* Paley's Natural Theology.

sympathy with the eye that is closed and opened. This change of the position of the eye-ball takes place during the most rapid winking motions of the eye-lids. When a dog was deprived of the power of closing the eye-lids of one eye by the division of the nerve of the eye-lids, the eye did not cease to turn up when he was threatened, and when he winked with the eye-lids of the other side.

In patients deprived of the motion of the orbicularis palpebrarum by paralysis, we see every effort to close the eye-lids attended with a turning up of the eye-ball.

Nearly the same thing I observed in a girl whose eye-lids were attached to the surrounding skin, owing to a burn; for the fore part of the eye-ball being completely uncovered, when she would have winked, instead of the eye-lids descending, the eye-balls were turned up, and the cornea was moistened by coming into contact with the mouths of the lachrymal ducts.

The purpose of this rapid insensible motion of the eye-ball will be understood on observing the form of the eye-lids and the place of the lachrymal gland. The margins of the eye-lids are flat, and when they meet they touch only at their outer edges, so that when closed there is a gutter left between them and the cornea. If the eye-balls were to remain without motion, the margins of the eye-lids would meet in such a manner on the surface of the cornea, that a certain portion would be left untouched, and the eye would have no power of clearing off what obscured the vision, at that principal part of the lucid cornea which is in the very axis of the eye; and if the tears flowed, they would be left accumulated on the centre of the cornea, and winking, instead of clearing the eye, would suffuse it. To avoid these effects, and to sweep and clear the surface of the cornea, at the same time that the eye-lids are closed, the eye-ball revolves, and the cornea is rapidly elevated under the eye-lid.

Another effect of this motion of the eye-ball is to procure the discharge from the lachrymal ducts; for by the simultaneous ascent of the cornea, and the descent of the upper eye-lid, the membrane on which the ducts open is stretched, and the effect is like the elongation of the nipple, facilitating the discharge of tears.

By the double motion, the descent of the eye-lid, and the ascent of the cornea at the same time, the rapidity with which the eye escapes from injury is increased. Even creatures which have imperfect eye-lids, as fishes, by possessing this rapid revolving motion of the eye, avoid injury and clear off impurities.

I may observe in passing, that there is a provision for the preservation of the eye, in the manner in which the eye-lids close, which has not been noticed; while the upper eye-lid falls, the lower eye-lid is moved towards the nose. This is a part of that curious provision for collecting offensive particles towards the inner corner of the eye. If the edges of the eye-lids be marked with black spots, it will be seen that, when the eye-lids are opened and closed, the spot on the upper eye-lid will descend and rise perpendicularly, while the spot on the lower eye-lid will play horizontally like a shuttle.

To comprehend certain actions of the muscles of the eye, we must remember that the caruncle and membrane called *semilunaris*, seated in the inner corner of the eye, are for ridding the eye of extraneous matter, and

are, in fact, for the same purpose with that apparatus which is more perfect and appropriate in beasts and birds.

In quadrupeds there is a gland for secreting a glutinous and adhesive fluid, which is seated on that side of the orbit next the nose: it is quite distinct from the lachrymal gland; it is squeezed by an apparatus of muscles, and the fluid exudes upon the surface of the third eye-lid. This third eye-lid is a very peculiar part of the apparatus of preservation. It is a thin cartilage, the posterior part of which is attached to an elastic body. This body is lodged in a division or depression of the orbit on the side towards the nose. When the eye is excited, the eye-ball is made to press on the elastic body, and force it out of its recess or socket: the consequence of which is the protrusion of the cartilaginous third eye-lid, or *haw*, as it is termed in the horse. By this mechanism, the third eye-lid is made to sweep rapidly over the surface of the cornea, and, by means of the glutinous fluid with which its surface is bedewed, it attaches and clears away offensive particles.

In birds, the eye is an exquisitely fine organ, and still more curiously, and, as we might be tempted to say, artificially protected. The third eye-lid is more perfect: it is membranous and broad, and is drawn over the surface of the eye by means of two muscles which are attached to the back part of the eye-ball, and by a long round tendon, that makes a course of nearly three parts of the circumference of the ball. The lachrymal gland is small, and seated low, but the mucous gland is of great size, and seated in a cavity deep and large, and on the inside of the orbit. As the third eye-lid is moved by an apparatus which cannot squeeze the mucous gland at the same time that the eye-lid is moved, as in qudrupeds, the oblique muscles are particularly provided to draw the eye-ball against the gland, and to force out the mucus on the surface of the third eye-lid. It flows very copiously; and this is probably the reason of the smallness of the proper lachrymal gland which lies on the opposite side of the orbit.

We already see two objects attained through the motion of these parts: the moistening the eye with the clear fluid of the lachrymal gland; and the extraction, or rather the protrusion, of offensive particles.

There is another division of this subject no less curious: the different conditions of the eye, during the waking and sleeping state, remain to be considered. If we approach a person in disturbed sleep, when the eye-lids are a little apart, we shall not see the pupil nor the dark part of the eye, as we should were he awake, for the cornea is turned upwards under the upper eye-lid. If a person be fainting, as insensibility comes over him the eyes cease to have speculation; that is, they want direction, and are vacant, and presently the white part of the eye is disclosed by the revolving of the eye-ball upwards. So it is on the approach of death; for, although the eye-lids be open, the pupils are in part hid, being turned up with a seeming agony, which is the mark of increasing insensibility.

It will now be admitted, that the variety of motions to which the eye is subjected require the complication of muscles which we find in the orbit; and it must be obvious to the most casual observer, that unless these various offices and different conditions of the eye be considered, it

will be in vain to attempt an accurate classification of the muscles of the orbit.

OF THE ACTIONS OF THE MUSCLES OF THE EYE, AND THEIR NATURAL CLASSIFICATION.

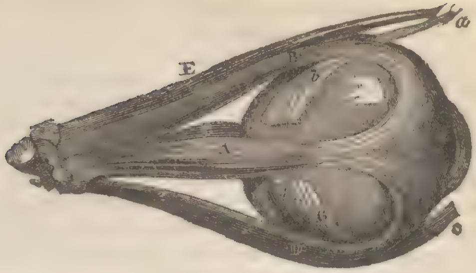
The muscles attached to the eye-ball are in two classes, the recti and obliqui. The recti muscles are four in number, and come from the bottom of the orbit, and run a straight course forwards and outwards: they embrace the eye-ball, and are inserted at four cardinal points into it. The obliqui are two muscles having a direction backwards and outwards*: they embrace the eye-ball, one passing over it obliquely, the other under it obliquely.

The muscles of the eye seen in front.

A. B. C. D. The recti muscles; voluntary muscles.
E. The superior oblique muscle or trochlearis.
a. The trochlea cut off from the bone and left attached to the tendon. It is a loop through which the tendon runs.
b. The tendon of the trochlearis muscle, expanding and running to its insertion.
G. The inferior oblique muscle. It is seen, like the tendon of the superior oblique, to run backwards and outwards.

That the recti muscles perform the office of directing the axis of the eye, turning it round to every point in the sphere of vision, there are many proofs. In the first place, their origin, course, and insertion, accurately fit them for this office; and they are obviously equal to it, unassisted by other muscles. In the next place, from man down to the cuttle-fish, the voluntary motions of the eyes are the same, and the origin, course, and insertion of these muscles are similar, while the other muscles vary with the change of apparatus which is around the eye.

* We may say so; for, although the superior oblique muscle comes from the back of the orbit, yet, by passing through the trochlea, it has a course backwards and outwards to its insertion.



The muscles of the eye seen in profile.

A. B. C. D. Three of the recti muscles. They arise together from the periosteum of the bottom of the orbit, and are inserted into the anterior part of the sclerotic coat of the eye.
E. The superior oblique muscle, or trochlearis.
a. The trochlea.
b. The reflected tendon inserted into the back and outer part of the sclerotic coat.
G. the inferior oblique muscle.
c. Its origin from the anterior part of the orbit.
d. Its insertion into the back and outer part of the eye-ball.

The oblique muscles of the eye stand contrasted with the recti in every respect; in number, size, and direction. Yet it is a received opinion, that they antagonise the recti, and keep the eye suspended. To this opinion there are many objections. 1. In creatures where the eye is socketed on a cup of cartilage, and cannot retract, the oblique muscles are nevertheless present. 2. Where a powerful retractor muscle is bestowed in addition to the recti muscles, the oblique muscles have no additional magnitude given to them. 3. In matter of fact, the human eye cannot be retracted by the united action of the recti, as we see quadrupeds draw in their eyes, which is an argument against these muscles being retractors, and therefore against the obliqui being their opponents, to draw it forward.

By dissection and experiment it can be proved, that the oblique muscles are antagonists to each other, and that they roll the eye in opposite directions, the superior oblique directing the pupil downwards and outwards, and the inferior oblique directing it upwards and inwards. But it is proved that any two of the recti muscles are equal to the direction of the pupil in the diagonal between them; and there is no reason why an additional muscle should be given, to direct the pupil upwards and inwards more than upwards and outwards, or downwards and inwards. It is evident, then, that the oblique muscles are not for assisting the recti in directing the eye to objects, but that they must have some other appropriate office. If we proceed farther, it must be by experiment.

To these, other objections, no less strong, may be added. We have just found that certain very rapid motions are to be performed by the eye-ball: now it can be demonstrated, that a body will be moved in less time by a muscle which is oblique to the line of motion, than if it lay in the line on which the body moves. If the oblique muscles were either

opponents or coadjutors of the recti, there appears no reason why they should be oblique, but the contrary; for as the points of their insertion must move more rapidly than those of the recti, they are unsuitable. On the other hand, that there may be no difference in the time of the action and relaxation of the several classes, we see a reason why one rectus should be opposed by another, and why, there being occasion for one oblique, its antagonist should also be oblique.

In proportion as a muscle gains velocity by its obliquity, it loses power; from the obliquity, therefore, of these muscles believed to be opposed to the recti, and from their being two of them to four of the latter, they are disproportioned in strength, and the disproportion proves that the two classes of muscles are not antagonists.

EXPERIMENTAL ENQUIRY INTO THE ACTION OF THESE MUSCLES.

I. I divided the *superior rectus* or *attollens* in a rabbit, and felt something like disappointment on observing the eye remain stationary. Shortly afterwards, on looking to the animal while it was feeding, I saw the pupil depressed, and that the animal had no power of raising it.

The explanation I conceive to be this: during the experiment the eye was spasmodically fixed by the general action of the muscles, and particularly by the powerful retractor, a muscle peculiar to quadrupeds. But on the spasm relaxing, and when the eye was restored to the influence of the voluntary muscles, the recti, the voluntary power of raising the eye being lost by the division of the superior muscle, the eye was permanently depressed.

II. Wishing to ascertain if the oblique muscles contract to force the eye-ball laterally towards the nose, I put a fine thread round the tendon of the superior oblique muscle of a rabbit, and appended a glass bead to it of a weight to draw out the tendon a little. On touching the eye with a feather, I had the pleasure of seeing the bead drawn up. And, on repeating the experiment, the thread was forcibly drawn through my fingers.

By experiments made carefully in the dead body (having distended the eye-ball by dropping mercury into it to give it its full globular figure), I had found that the action of the superior oblique muscle is to turn the pupil downwards and outwards, and that the inferior oblique just reverses this motion of the eye. In the above experiment there is abundance of proof that the superior oblique muscle acted, and yet the pupil was not turned downwards and outwards, therefore both oblique muscles must have been in action. Their combined action draws the eye-ball towards the nose.

In the violent spasmodic affection of the eye, when it is painfully irritated, I believe that all the muscles, both of the eye-ball and eye-lids, are excited. In quadrupeds, I have ascertained that the oblique muscles act when the haw is protruded; but I have also found, that the retractor oculi alone is capable of forcing forwards the haw.

But quadrupeds, having an additional apparatus of muscles to those of the human eye, are not suited for experiments intended to illustrate

the motions of our eyes. The monkey has the same muscles of the eye with man.

III. I cut across the tendon of the superior oblique muscle of the right eye of a monkey. He was very little disturbed by this experiment, and turned round his eyes with his characteristic enquiring looks, as if nothing had happened to affect the eye.

IV. I divided the lower oblique muscle of the eye of a monkey. The eye was not, in any sensible manner, affected: the voluntary motions were perfect after the operation.

V. On holding open the eyes of the monkey, which had the superior oblique muscle of the right eye divided, and waving the hand before him, the right eye turned upwards and inwards, while the other eye had a scarcely perceptible motion in the same direction. When the right eye was thus turned up, he seemed to have a difficulty in bringing it down again.

From experiments it is proved, that the division of the oblique muscles does not in any degree affect the voluntary motions by which the eye is directed to objects.

This cannot, however, be said of the involuntary winking motions of the eyes. We have seen that in winking to avoid injury, the oblique muscles were in operation; and that the inferior oblique muscle gained in the power of elevating the eye-ball by the division of the superior oblique, its opponent.

These revolving motions, accompanying the winking motions of the eye-lids, are of the utmost consequence to the preservation of the organ. A case which was some time under my observation proved this. By a defect of motion, the eye and eye-lids remained fixed, and the consequence was that the cornea inflamed and became opaque. Another curious circumstance in this case was, that when the eye-lids were closed, the patient still saw red light through the affected eye, the reason of which was that the eye-ball did not turn up when the eye-lid was closed.

If we close the eyes opposite to the window or before a candle, and continue to attend to the sensations of the eye, we shall still see red light coming through the eye-lids. But if we make an effort to close the eye-lids (though they be already shut), we shall be in momentary darkness, because during the effort the eye-balls are then turned up. Thus it appears that the dropping of the eye-lid would make but an imperfect curtain before the eye, and the eye, to be entirely protected from the light, must have the pupil turned upwards.*

* In the case above alluded to, the patient had lost both motion and the common sensibility of the eye; the office of the fifth nerve was lost, yet the optic nerve retained its power, and he could see.

ON THE TWO CONDITIONS OF THE EYE, ITS STATE OF REST, AND OF ACTIVITY.

The eye is subject to two conditions: a state of rest, with entire oblivion of sensation; and a state of watchfulness, during which both the optic nerve and the nerve of voluntary motion are in activity. When the eye is at rest, as in sleep, or even when the eye-lids are shut, the sensation on the retina being then neglected, the voluntary muscles resign their office, and the involuntary muscles draw the pupil under the upper eye-lid. This is the condition of the organ during perfect repose.

On the other hand, there is an inseparable connection between the exercise of the sense of vision and the exercise of the voluntary muscles of the eye. When an object is seen, we enjoy two senses: there is an impression upon the retina; but we receive also the idea of position or relation, which it is not the office of the retina to give. It is by the consciousness of the degree of effort put upon the voluntary muscles, that we know the relative position of an object to ourselves. The relation existing between the office of the retina and of the voluntary muscles may be illustrated in this manner.

Let the eyes be fixed upon an illuminated object until the retina be fatigued, and in some measure exhausted by the image; then, closing the eyes, the figure of the object will continue present to them: and it is quite clear that nothing can change the place of this impression on the retina. But, notwithstanding that the impression on the retina cannot be changed, the idea thence arising may. For, by an exertion of the voluntary muscles of the eye-ball, the body seen will appear to change its place; and it will, to our feeling, assume different positions, according to the muscle which is exercised. If we raise the pupil, we shall see the body elevated; or, if we depress the pupil, we shall see the body placed below us: and all this takes place while the eye-lids are shut, and when no new impression is conveyed to the retina. The state of the retina is here associated with a consciousness of muscular exertion; and it shows that vision in its extended sense is a compound operation, the idea of position of an object having relation to the activity of the muscles.

We may also show, by varying this experiment, that an agitated state of the muscles, or a state of action where the muscles are at variance or confused, affects the idea of the image. If we look on the luminous body so as to make this impression on the retina, and then cover the face so as to exclude the light, keeping the eye-lids open, and if we now squint, or distort the eyes, the image which was vividly impressed upon the retina instantly disappears as if it were wiped out. Does not this circumstance take place, because the condition of the muscles thus unnaturally produced, being incongruous with the exercise of the retina, disturbs its operation?

If we move the eye by the voluntary muscles, while this impression continues on the retina, we shall have the notion of place or relation raised in the mind; but if the motion of the eye-ball be produced by any other cause, by the involuntary muscles, or by pressure from without, we shall have no corresponding change of sensation.

If we make the impression on the retina in the manner described,

and shut the eyes, the image will not be elevated, although the pupils be actually raised, as it is their condition to be when the eyes are shut, because there is here no sense of voluntary exertion. If we sit at some distance from a lamp which has a cover of ground-glass, and then fix the eye on the centre of it, and then shut the eye and contemplate the phantom in the eye; and if, while the image continues to be present of a fine blue colour, we press the eye aside with the finger, we shall not move that phantom or image, although the circle of light produced by the pressure of the finger against the eye-ball moves with the motion of the finger.

May not this be accounted for in this manner? the motion produced in the eye-ball not being performed by the appropriate organs, the voluntary muscles, it conveys no sensation of change to the sensorium, and is not associated with the impression on the retina, so as to affect the idea excited in the mind. It is owing to the same cause that, when looking on the lamp, by pressing one eye, we can make two images, and we can make the one move over the other. But, if we have received the impression on the retina so as to leave the phantom visible when the eye-lids are shut, we cannot, by pressing one eye, produce any such effect. We cannot, by any degree of pressure, make that image appear to move, but the instant that the eye moves by its voluntary muscles, the image changes its place; that is, we produce the two sensations necessary to raise this idea in the mind: we have the sensation on the retina combined with the consciousness or sensation of muscular activity.

These experiments, and this explanation of the effect of the associated action of the voluntary muscles of the eye-ball, appear to me to remove an obscurity in which this subject has been left by the latest writers. In a most scientific account of the eye and of optics, lately published by Dr. Brewster, it is said on this question, "We know nothing more than that the mind residing, as it were, in every point of the retina, refers the impression made upon it, at each point, to a direction coinciding with the last portion of the ray which conveys the impression." The same author says, "Kepler justly ascribed erect vision from an inverted image to an operation of the mind, by which it traces the rays back to the pupil, and thus refers the lower part of the image to the upper side of the eye." What can be here meant by the mind following back the ray through the humours of the eye? It might as well follow the ray out of the eye. A greater authority says, we puzzle ourselves without necessity.—"We call that the lower end of an object which is next the ground." No one can doubt that the obscurity here is because the author has not given himself room to illustrate the subject by his known ingenuity and profoundness. But it appears to me, that the utmost ingenuity will be at a loss to devise an explanation of that power by which the eye becomes acquainted with the position and relation of objects, if the sense of muscular activity be excluded, which accompanies the motion of the eye-ball.

Let us consider how minute and delicate the sense of muscular motion is by which we balance the body, and by which we judge of the position of the limbs, whether during activity or rest. Let us consider how imperfect the sense of touch would be, and how little of what is actually known through the double office of muscles and nerves would be at-

tained by the nerve of touch alone, and we shall be prepared to give more importance to the recti muscles of the eye, in aid of the sense of vision;—to the offices performed by the frame around the eye-ball in aid of the instrument itself.

OF THE EXPRESSION OF THE EYE, AND OF THE ACTIONS OF THE OBLIQUE MUSCLES IN DISEASE.

During sleep, in oppression of the brain, in faintness, in debility after fever, in hydrocephalus, and on the approach of death, the pupils of the eyes are elevated. If we open the eye-lids of a person during sleep or insensibility, the pupils will be found elevated. Whatever be the cause of this, it will be found that it is also the cause of the expression in sickness, and pain, and exhaustion, whether of body or mind; for then the eye-lids are relaxed and fallen, and the pupils elevated so as to be half covered by the upper eye-lid. This condition of the eye, during its insensible unexercised state, we are required to explain.

It is a fact familiar to pathologists, that when debility arises from affection of the brain, the influence is greatest on those muscles which are, in their natural condition, most under the command of the will. We may perceive this in the progressive stages of debility in the drunkard, when successively the muscles of the tongue, the eyes, the face, the limbs, become unmanageable; and, under the same circumstances, the muscles which have a double office, as those of the chest, lose their voluntary motions, and retain their involuntary motions, the force of the arms is gone long before the action of breathing is affected.

If we transfer this principle, and apply it to the muscles of the eye, we shall have an easy solution of the phenomena above enumerated. The recti are voluntary muscles, and they suffer debility before the oblique muscles are touched by the same condition; and the oblique muscles prevailing, roll the eye.

If it be farther asked, Why does the eye roll upwards and inwards? We have to recollect, that this is the natural condition of the eye, its position when the eye-lids are shut and the light excluded, and the recti at rest and the obliqui balanced.

Although I am aware that medical histories do not often lead to the improvement of strict science, yet I am tempted to describe the condition of a patient now under my care, because it exhibits a succession of those phenomena which we seek to explain. He presented himself to me in the hospital with a distinct squint, the left eye being distorted from the object. On the eye-lid of the right eye there was a deep venereal ulcer: the man was in danger of losing the right eye, and required prompt assistance; but, before he could be brought under the influence of mercury, the inflamed sore became deeper and the cornea opaque. The superior rectus muscle being, as I suppose, injured by the increasing depth of the sore, the pupil became permanently depressed. The sight of the right eye being now lost, the left eye came into use: it was directed with precision to objects; he had no difficulty in using it, and it daily became stronger.

After a few weeks, medicine having had its influence, the sore on the upper eye-lid of the right eye healed, the inflammation and opacity of

the eye gradually diminished, the light became again visible to him: first it was yellow, and then a deep purple. And now the muscles resumed their influence, and the eye was restored to parallel motion with the other, and so as considerably to embarrass the vision. But the inflammation of the upper eye-lid had been so great as to diminish its mobility; and, what appeared most extraordinary, the lower eye-lid assumed the office of the upper one, and a very unusual degree of motion was remarked in it. It was depressed when he attempted to open the eye, and elevated and drawn towards the nose, when he closed the eye. But the upper eye-lid was not only stiff, but diminished in breadth; so that, notwithstanding the remarkable elevation of the lower eye-lid, their margins could not be brought together, and we could perceive the motion of the eye-ball: in his attempt to close the eye we constantly saw the pupil elevated, and the white part of the eye exposed.

I shall now attempt the explanation of these phenomena.

The impression upon the left eye had been weak from infancy, and the retina being unexercised, the recti, or voluntary muscles, wanted their excitement, and were deficient in activity; the involuntary muscles therefore prevailed, and the pupil was turned upwards and inwards, and consequently removed from the axis of the other eye. But when that other eye became obscured, the left eye being the only inlet to sensation, the attention became directed to the impression on the retina, the voluntary muscles were excited to activity, and they brought the eye to bear upon objects. This eye improved daily, because the natural exercise of a part is its stimulus to perfection, both in function and in growth. When the right eye became transparent, and the light was admitted, the voluntary muscles of that eye partook of their natural stimulus, and commenced that effort in search of the object, which in the course of a few days brought the eye to its proper axis, and both eyes to parallelism.

The next thing that attracts our attention in this short narrative is the revolving of the eye-ball. It has been explained in a former part of the paper, that when the eye-lids are shut, the recti, or voluntary muscles, resign their office, and the inferior oblique muscle gains power, and the eye-ball traverses so as to raise the pupil. It will not have escaped observation, that the pupil of this eye was depressed, and could not be elevated by a voluntary act for the purpose of vision, owing, as we have supposed, to the injury of the rectus attollens, at the same time that it was thus raised involuntarily, in the attempt to shut the eye—a proof that this insensible motion is performed by the lower oblique muscle, and not the superior rectus muscle.

The circumstance of the lower eye-lid assuming the functions of the upper one, and moving like the lower eye-lid of a bird, reminds me of an omission in the account of authors. They have sought for a depressor of the inferior eye-lid, which has no existence, and is quite unnecessary; for the motion of the *M. elevator palpebræ superioris* opens wide the eye-lids, and depresses the lower eye-lid, at the same time that it elevates the upper eye-lid. If we put the finger on the lower eye-lid when the eye is shut, and then open the eye, we shall feel that during this action the eye-ball is pushed outwards; and we may observe, that the lower eye-lid is so adapted as to slip off the convex surface of the ball, and is

consequently depressed. The reason of this is, that the muscle which raises the upper eye-lid passes over a considerable part of the upper and back part of the eye-ball; and the origin and insertion of the muscle being under the highest convexity of the ball, that body must be pressed forwards in proportion to the resistance of the upper eye-lid to rise. In the preceding case, the upper eye-lid being stiff and unyielding, both the origin and insertion of the *elevator palpebræ* became fixed points; consequently, the action of the muscle fell entirely on the eye-ball itself, whereby it was forced downwards and forwards in an unusual manner, and so depressed the lower eye-lid to an unusual degree. Thus the muscle became a *depressor* of the inferior eye-lid, instead of an *elevator* of the upper eye-lid! The motion of elevation in the lower eye-lid was of course performed by an increased action of the lower portion of the *orbicularis palpebrarum*.

But it has been observed, that the shutting of the eye-lids is not the only part of the act of preservation, and that the motions of the eye-lids are attended with a rolling of the eye-ball. How is this relation between the eye-lids and eye-ball established? This leads to an examination of the fourth nerve, which could not be done before.

THE FOURTH NERVE.

We have seen that it takes its origin from the brain, at a part remote from all the other nerves which run into the orbit. It threads the intricacies of the other nerves without touching them, and is entirely given to one muscle, the superior oblique. We may observe, too, that this singularity prevails in all animals. What office can this nerve have in reference to this one muscle? Why is its root, or source, different from the other nerves, — from the nerve of vision, the nerve of common sensibility, and the nerve of voluntary motion? We now reflect, with increased interest, on the offices of the oblique muscles of the eye, observing that they perform an insensible rolling of the eye-ball, and hold it in a state of suspension between them. We have seen that the effect of dividing the superior oblique was to cause the eye to roll more forcibly upwards; and if we suppose that the influence of the fourth nerve is, on certain occasions, to cause a relaxation of the muscle to which it goes, the eye-ball must be then rolled upwards.*

The course of enquiry leads us, in the next place, to observe the vici-

* The nerves have been considered so generally as instruments for stimulating the muscles, without thought of their acting in the opposite capacity, that some additional illustration may be necessary here. Through the nerves is established the connection between the muscles, not only that connection by which muscles combine to one effort, but also that relation between the classes of muscles by which the one relaxes while the other contracts. I appended a weight to a tendon of an extensor muscle, which gently stretched it and drew out the muscle; and I found that the contraction of the opponent flexor was attended with a descent of the weight, which indicated the relaxation of the extensor. To establish this connection between two classes of muscles, whether they be grouped near together, as in the limbs, or scattered widely as the muscles of respiration, there must be particular and appropriate nerves to form this double bond, to cause them to conspire in relaxation as well as to combine in contraction. If such a relationship be established, through the distribution of nerves, between the muscles of the eye-lids and the superior oblique muscle of the eye-ball, the one will relax while the other contracts.

nity of the root of this fourth nerve to the origin of the respiratory of the face, and we find them arising from the same track of fibrous substance. The column of medullary matter, which constitutes that part of the medulla oblongata from which the respiratory nerves arise, terminates upwards, or at its anterior extremity, just under the corpora quadrigemina, and there the fourth arises. Is it possible, then, we say, that there can be any correspondence between the general act of respiration and the rolling of the eye? Led thus to make the experiment, I was gratified to find it so easy to give the proof. On stopping the nostrils with the handkerchief, every effort to blow the nose will be attended by a rapid rising of the cornea under the upper eye-lid. And on every occasion when the eye-lids suffer contraction through the agency of the respiratory nerve of the face, as in sneezing, the eye-ball is rolled upwards, undoubtedly through the agency of the fourth nerve.

It is plain that we must consider the nerves and muscles of the eye-lids in a double capacity — in their voluntary and involuntary actions. In the first, the motions of the eye-lids combine with the whole muscles of the eye-ball, as we may perceive in the voluntary contractions and squeezing of the eye; but in the insensible and involuntary motions of the eye-lids there would be no sympathy with the muscles of the eye-ball, and therefore no correspondence in the motion of these parts, without a nerve of the nature of the fourth; that is, a nerve which, having diverged from the root of the respiratory nerves, takes its course to the oblique muscles. In one word, the connection of its root declares the office of this nerve.

The expression of the eye in passion confirms the truth of this relation being established by a respiratory nerve, and, consequently, by a nerve of expression. In bodily pain, in agony of mind, and in all this class of passions, the eyes are raised and dragged, in conjunction with the changes to which the other features are subjected. If it be asked now, as it has been asked for some hundred years past, why the fourth nerve goes into the orbit, where there are so many nerves; why it is so distant in its origin from the other nerves; and why it sends off no twig or branch, but goes entirely to one muscle of the eye? the answer is, to provide for the insensible and instinctive rolling of the eye-ball; and to associate this motion of the eye-ball with the winking motions of the eye-lids; to establish a relation between the eye and the extended respiratory system: all tending to the security or preservation of the organ itself.

OF THE MANNER IN WHICH THE EYE ADAPTS ITSELF TO THE DISTANCE OF OBJECTS.

This is a question which many have endeavoured to answer, and many have failed: the proof of this is, that there is not *one* explanation of the manner in which the eye adapts itself to the distance of objects, but *many* explanations equally ingenious.

One opinion is, that the eye is at rest when we see the distant parts of a landscape, but that the direction of the eye to the nearer objects is attended with an effort. This effort is the action of the straight muscles of the eye compressing the ball of the eye, so as to lengthen the axis as

much as is necessary to allow the pencils of rays to unite in points upon the retina.

To this opinion it is objected, that in some animals the sclerotic is hard, and not capable of changing its figure; that in man the pressure would be unequal; that the unelastic retina would be thrown into irregular folds; that these muscles, being voluntary muscles under the will, we should be more conscious of their operation than we are; and that, while the mind remains attentive to distant objects, no voluntary exertion of these muscles can affect the distinctness of the objects. Again, to make the eye change its accommodation from the distinct vision of objects, at six inches to fourteen feet five inches, would require such a pressure as might lengthen the axis of the eye one tenth part, which again would form an oval that would derange the retina.

Another opinion is, that when the eye sees the nearest objects it is at rest, and that, in attending to distant objects, the straight muscles draw back the fore part of the eye into the socket, and thus shorten the axis. To this opinion, of course, the same objections lie as to the supposition that the axis is lengthened by the operation of the muscles.

I must say, that it appears to me, if the effect contemplated were referable to the changing the configuration of the eye, we should be sensible of a shift in the position of all objects seen lateral to the axis of vision, and that, by looking to objects afar off, we should diminish or extend the field of vision laterally. I can observe no such effect.

There are some who have entertained an opinion, that the iris, by its contraction, operates so on the circular margin of the cornea, where it is connected with the sclerotic coat, as to make the cornea more convex, and thus increase its power of concentrating the rays, and enable the eye to see near objects distinctly. To account for this power in the iris, Dr. Jurin, the proposer of this hypothesis, supposes that there is a greater muscular ring in the margin of the iris connected with the edge of the cornea; the existence of these muscular fibres is not demonstrated; but he says, since the lesser muscular ring in the inner margin of the iris is not proved by ocular inspection, and yet is justly inferred from its effects, viz. the contraction of the pupil; in the same way, "the change of conformation in the eye has not yet been adequately accounted for, but may be fairly made out by supposing the existence of the greater muscular ring." His conclusion is in these words:—"When we view objects nearer than the distance of fifteen or sixteen inches, I suppose the greater muscular ring of the iris contracts, and thereby reduces the cornea to a great convexity; and, when we cease to view these near objects, this muscular ring ceases to act, and the cornea, by its spring, returns to its usual convexity, suited to fifteen or sixteen inches: in which condition the elasticity of the cornea on the one side, and the tone of the muscular ring on the other, may be considered as two antagonists in a perfect equilibrium."

To this opinion it is objected, that the iris is not rooted in the cornea, but in the sclerotic coat, which is firm in man, and inflexible in many animals. We have also to consider, that this delicate and invisible circle of muscular fibres has not only to contract the margin of the cornea, but, in this action, to alter the configuration of the whole eye. The eye-ball is a whole equally distended, and no part of it can suffer contraction

without a resistance from the whole of the coats; besides, in this case, the alternation of light and the brightness of objects would be perpetually obscuring the image, by the play of the iris causing an alteration of the focus of the cornea. But Dr. Jurin did not attribute the whole effect to the action of the iris. He thus explains the use of the fluid surrounding the lens and the membranous capsule:—When the eye is to be suited to greater distances, he supposed that the ligamentum ciliare contracts its longitudinal fibres, and, by that means, draws the part of the interior surface of the capsule, into which these fibres are inserted, a little forward and outward. By this action, he supposed that the fluid within the capsule of the lens flows from the middle towards the margin; and, consequently, the centre of the capsule of the lens is reduced to a less degree of convexity; and that the elasticity of the capsule, and the tone of the ligament, may be looked upon as two antagonists perfectly in equilibrio with one another. In the state of rest, the eye is conceived, by Dr. Jurin, to be adapted to the middle distance; by the increase of the convexity of the cornea, to be adapted to nearer vision; and, by the change in the capsule of the lens, to be fitted to distant objects.

To this last supposition it is objected, that there is a simplicity in the operations of Nature; that the change wrought upon the capsule of the lens is insufficient to account for the whole effect, and that, therefore, there is a presumption that it has no share in producing the change; that there are no muscular fibres in the ciliary processes; and, lastly, that this fluid, being of density but little, if at all, removed from the aqueous humour, any alteration of its form can have but a very insignificant effect.

It has occurred to others,* that the oblique muscles of the eye-ball, being thrown in opposite directions round it, they may have the effect of elongating the axis of the eye: again, that the action of the orbicularis muscle of the eye-lids, by compressing the eye-ball, assists in accommodating the eye for seeing near objects more distinctly. Dr. Monro makes a set of experiments to prove the effect of the orbicularis muscle of the eye-lids; but I conceive that he has deceived himself, in ascribing to the compression of the eye-lids an effect partly produced by a voluntary effort, but in a way which is not understood, and partly by the contraction and dilatation of the pupil, from the degree of opening of the eye-lids. If he be right in his way of accounting for the effects produced in the experiments which he details, they ought to have the effect of precluding the necessity of all further hypothesis; so fully does the action of the orbicularis muscles seem to him adapted to the end proposed. In the first experiment, when he opened his eye-lids wide, and endeavoured to read a book, the letters on which were so near the eye as to be indistinct, he found that he could not do it. In the second experiment, keeping the head in the same relation to the book, he brought the edges of the eye-lids within a quarter of an inch of each other, and then made an exertion to read, when he found he could see the letters and words distinctly. When I try this experiment I find the action of the eye-lids to have no sensible effect, unless they are brought very close together: then I do, indeed, find that they have a most

* Hambergerus, Briggs, Keil, Monro.

remarkable effect. But, in this situation, the eye-lids cover the cornea so much, that if they have any effect at all upon the cornea, it must be to compress and flatten it, and not to give it a greater convexity. The smaller the opening of the eye-lids, the greater I found the effect: I conceive it to be produced by the optical effect of the eye-lashes correcting the too great converging of the rays; and the same effect I found to be produced by the marginal hairs of two flat camel-hair brushes, although the eye-lids were kept open. Dr. Monro concludes that, in this action of the eye, 1st, the iris; 2ndly, the recti muscles; 3dly, the two oblique muscles; and, 4thly, the orbicularis palpebrarum, have all their share in accommodating it to the distance of objects, and in giving perfect vision.

Very ingenious experiments are made by Dr. Young,* to determine whether there be any change in the length of the axis of the eye-ball. He considers it as necessary, to account for the power of the eye in adapting it to the distance of objects, that the diameter should be enlarged one seventh: its transverse diameter diminished one fourteenth; and the semi-diameter shortened one thirtieth of an inch. To determine this he fixed the eye, and at the same time he forced in upon the ball of the eye the ring of a key, so as to cause a phantom very accurately defined to extend within the field of perfect vision; then, looking to bodies at different distances, he expected, if the figure of the eye was altered, that the spot, caused by the pressure, would be altered in shape and dimensions; he expected that, instead of an increase of the length of the eye's axis, the oval spot caused by the pressure of the key, resisting this elongation, should have spread over a space at least ten times as large as the most sensible part of the retina: but no such effect took place; the power of accommodation was as extensive as ever, and there was no perceptible change either in the size or in the figure of the oval spot. Again, he placed two candles so as exactly to answer to the extent of the termination of the optic nerve: he marked accurately the point to which the eye was directed; he then made the utmost change in its focal length, expecting that, if there were any elongation of the axis, the external candle would appear to recede outward upon the visible space; but this did not happen; the apparent place of the obscure part was precisely the same as before.

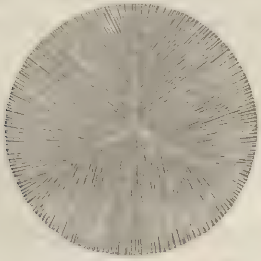
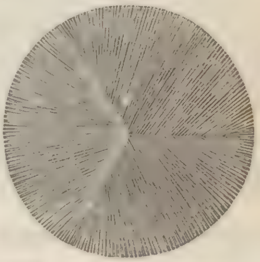
A favourite opinion of late has been, that the lens has a power of altering its degree of convexity, and thus accommodating itself to the distance of objects. As to the fibrous structure of the lens, there can be no doubt: first it is rent by fissure, then split into lamina, and can be finally teased out into fibres.

This structure was first observed by Leeuwenhoeck; he has these words: — "Porro vidi corpus crystallinum ex tam tenuibus coacervatis constare squamis ut ubi eas oculo dimetior, dicere cogar, pluris bis millenis sibi invicem incumbere; ubi enim corpus crystallinum ab ejus membranula seperassem, ejus adhuc axis, ubi crassissimum erat, (non enim est perfecte rotundum, sed aliquo modo planum,) duas tertias pollicis partes retinebat; ergo a centro ad circumferentiam est tertia pollicis pars, atque quoniam, ex dimensione mea 600 pili lati pollicis quadrati,

* Philos. Trans. for 1810.

longitudinem conficiunt 200 pili lati pollicis tertiam partem adæquare debent. Atque nunc video ubi denæ squamæ sunt coacervatæ, eas capilli nostri diametrum nondum adæquare; ergo his 10 cum 200 multiplicatis, sequetur, ut dictum, plures 2000 squamas in corpore crystallino esse coacervatas. Porro vidi singulas has squamas ex filamentis, concinno ordine juxta se positis, constare adeo ut singulæ squamulæ unum filamentum sint crassæ; et ut hanc substantiam fibros eam ex qua corpus crystallinum constat ob oculos ponerem, eam lineis in circulum ductis quantum pote designavi."

The fibrous structure and muscularity of the lens was brought forward by Descartes, as explaining some actions of the eye; but was again neglected, till more lately, that it has been revived by the insertion of Dr. Young's Observations on Vision in the Philosophical Transactions.* The following are Dr. Young's observations on the appearance of the lens: — "The crystalline lens of the ox is an orbicular convex transparent body, composed of a considerable number of similar coats, of which the exterior closely adheres to the interior. Each of these coats consists of six muscles, intermixed with a gelatinous substance, and attached to six membranous tendons. Three of the tendons are anterior, three posterior; their length is about two thirds of the semidiameter of the coat; their arrangement is that of three equal and equidistant rays, meeting in the axis of the crystalline: one of the anterior is directed towards the outer angle of the eye, and one of the posterior towards the inner angle, so that the posterior are placed opposite to the middle of the interstices of the anterior; and planes passing through each of the six, and through the axis, would mark on either surface six regular equidistant rays. The muscular fibres arise from both sides of each tendon; they diverge till they reach the greatest circumference of the coat, and, having passed it, they again converge till they are attached respectively to the sides of the nearest tendons of the opposite surface. The anterior or posterior portion of the six, viewed together, exhibits the appearance of three penniform radiated muscles. The anterior tendons of all the coats are situated in the same planes, and the posterior ones in the continuations of these planes beyond the axis. Such an arrangement of fibres can be accounted for on no other supposition than that of muscularity. The mass is enclosed in a strong membranous capsule, to which it is loosely connected by minute vessels and nerves; and the connection is more observable near its greatest circumference. Between the mass and its capsule is found a considerable quantity of an aqueous fluid, the liquid of the crystalline."

* See vol. for 1793.

These mucular fibres could not be excited by Dr. Young so as to change the focal power. The same author states, that nerves enter the lens. I cannot say I see any tending that way. Supposing that these are muscular fibres*, from their closeness and direction, they would stand acknowledged as forming the strongest and most powerful muscle of its size in the whole body ; yet they act only on themselves, which requires the least possible degree of power. Again, how are they relaxed ? What power is their antagonist ? As to the tendons, I do not see their use. Does not the lens act merely on itself ? It can require no concentrating of its fibres into tendons ; for tendons are found in other parts of the body only where it is necessary to concentrate the whole power of the muscle so as to operate on one point. We know that the transparency of a substance depends on a certain arrangement of its fibres. Would not this change of position in the lens affect its transparency ? The effect is observed in the cornea.

However successfully the admirable methods of Dr. Young may have decided the matter as to the conformation of the eye-ball, he has not satisfied me that the power of adaptation is in the lens.

We learn from Sir Everard Home†, that Mr. John Hunter had proved the lens to be laminated, and those laminæ to be composed of fibres ; and, upon the same authority, we learn that his opinion was in favour of the muscularity of its structure. Sir E. Home wished to follow out this subject, by including it in the Croonian Lecture. He, with the assistance of Mr. Ramsden, thought he had determined that a patient, after the extraction of the cataract, still retained the power of adapting the eye to the distances of objects. Dr. Young, on the contrary, is positive that, in those who have lost the crystalline humour by operation, the focal distance is totally unchangeable.

By Mr. Ramsden's ingenious contrivance, the head was fixed accurately, and at the same time a microscope was adapted to observe the changes in the convexity of the cornea, as the eye was directed alternately to near and to distant objects. In these experiments, the motion of the cornea became distinct ; its surface remained in a line with a wire which crossed the glass of the microscope when the eye was adjusted to the distant objects, but projected considerably beyond it when adapted to the near ones, and the space through which it moved was so great as readily to be measured by magnifying the divisions on the scale, and comparing them. In this way it was estimated that it moved the 830th part of an inch (a space distinctly seen in a microscope magnifying 30 times), in the change from the nearest point of distinct vision to the distance of 90 feet.

In the evidence from anatomical structure, I cannot think Sir E. Home so happy. He was desirous of determining, more accurately than had hitherto been done, the precise insertion of the tendons of the four straight muscles, so as to know whether their action could be extended to the cornea or not : he found them to approach within $\frac{1}{8}$ of the cornea before their tendons became attached to the sclerotic coat. But he did not stop here : he stripped off with them the anterior lamina of the cor-

* The fibrous structure of the lens is represented according to Leeuwenhoeck.
† See Philos. Trans.

nea. Now, as it is supposed, in these experiments, that the action of the recti muscles upon the sides and back part of the ball compresses the humours, and makes them flow forward so as to distend the cornea; if the extremities of the tendons be inserted into the edge of the cornea, and even pass over it, as Sir E. Home has demonstrated, their effect would be to flatten the cornea, by drawing out and extending its margin. This is a circumstance which Dr. Monro has remarked; and he has found "all the tendinous fibres of the recti muscles firmly attached to the sclerotic coat at the distance of a quarter of an inch from the cornea, and no appearance that any part of them, or that any membrane produced by them, is continued over the cornea."

Dr. Young's experiment appears to be decisive of the question as regards the cornea. He destroyed the influence of the cornea, and still the eye possessed its range! He did this in the most ingenious manner, by inserting upon his eye a lens with its circular case full of water. The water touched the cornea, and intervened betwixt the cornea and the glass. Consequently, as the power of the cornea exists only by the difference of density of the air and cornea, and as by the interposition of water this power was destroyed, the eye continuing in possession of its ability to adapt itself to distances, this property could not depend on the cornea.

Amongst the variety of opinions, the innumerable, ingenious, but contradictory experiments for discovering the manner in which the eye adapts itself to the distance of objects, I am, for my own part, much at a loss to determine which I should prefer. I have often doubted whether these experimenters were not in search of the explanation of an effect which has no existence. I have never been able to determine, why a very slight degree of convexity in the cornea of a short-sighted eye should be so permanent during a whole lifetime, were the cornea elastic in the manner supposed, and capable of being altered in its convexity by the action of muscles. A near-sighted person, with the assistance of a concave glass, can command the objects to the distance of some miles, and, with the glass still held to his eye, can see minute objects within three inches of the eye. Now, I cannot conceive how the concave glass should give so great a range to the sight: as there can be no change in the glass, it must be the eye which adapts itself to the variety of distances; yet, without the glass, it cannot command the perfect vision of objects for a few feet. Again, a short-sighted person sees an object distinctly at three inches distant from the eye; at twelve feet, less distinctly; and, when he looks upon the object at twelve feet, the objects beyond it are confused, just as they appear to other men; but when he directs his attention to the more remote objects, those nearer become indistinct. Now, this indistinctness of the object, seen when he examines narrowly the objects beyond them, would argue (did we admit this muscular power in the eye of adapting itself to objects) that the cornea or the lens has become less convex, were we not previously convinced that the utmost powers of the eye could not bring the object at the distance of twelve feet, or any other intermediate distance, to be more distinctly seen that the fixed and permanent constitution of the eye admits.

I cannot help concluding, therefore, that the mechanism of the eye

has not so great a power of adapting the eye to various distances as is generally imagined, and that much of the effect attributed to mechanical power is the consequence of the motion of the pupil, the effect of light and of attention. An object looked upon, if not attended to, conveys no sensation to the mind. If one eye is weaker than the other, the object of the stronger eye alone is attended to, and the other is entirely neglected: if we look through a glass with one eye, the vision with the other is not attended to. Now, objects, as they recede from us, become fainter and fainter in their colours, and the general effect upon the eye is different from those which are near; and as it happens that the mind must associate with the sensation before it be perfect, there is, consequently, an obscurity thrown over distant objects when we contemplate near ones; as, on the other hand, the images of near ones are not attended to when the mind is occupied with distant ones, although they be nearly in the line with the distant object examined. The mind, not the eye, harmonises with the state of sensation, brightening the objects to which we attend. In looking on a picture, or a panorama, we look to the figures, and neglect the back-ground, or we look to the general landscape, and do not perceive the near objects. In short, we experience the whole phenomena presented to the eye when the shades and colours of nature are presented to us from a plane surface, as when the eye opens on all the varieties of a natural scene. It cannot be an adaptation of the eye, but an accommodation and association of the mind with the state of impression.

OF VISION.

The eye is certainly the noblest of the organs of sense. It is that with which we should part the most unwillingly, and of which, when deprived, we are most helpless. A celebrated philosopher says, how much more noble is that faculty by which we can find our way in the pathless ocean, traverse the globe, determine its figure and dimensions, delineate every region of it; by which we can measure the planetary orbs, and make discoveries in the sphere of the fixed stars! While another says, it is the universe itself! We are present with the stars which beam upon us, at a distance that converts to nothing the wide diameter of our planetary system. The other senses are the ties which bind us to our dwelling-place, whilst the eye retains the unbounded freedom of the celestial origin.* Yet, notwithstanding the perfection of the sense of seeing, much of this perfection is gained by the other senses, and particularly by that of touch. If the human body were motionless and inert, the sensation conveyed by the eye would be very imperfect: we should be able to conceive neither the distance nor the figure of objects. But, as it is, the visible magnitude of an object is the sign of its real magnitude; which knowledge we have acquired by other means. When we look upon an object, we have its visible figure before

* Brown.

us, as the sign of its real figure, which, by experience, that is, by motion of the hand, by approach, and the actual comparison with our own bodies, we have in a manner more perfect previously ascertained. Without this combination of actual experience and true knowledge, with the associated signs in the eye, vision would be a continual delusion.

Upon other occasions, we are apt enough to acknowledge the powers of association. But the connection of ideas is in no instance more constant and secret than in those conveyed by sight and touch. When a solid body is presented to view, we see only the light and shade; but this raises in our mind the associated ideas from the sense of touch, of solidity, convexity, and angularity, " the visible idea exciting in us those tangible ideas," which, in the free and promiscuous exercise of our senses, usually accompany it. It is thus that we attribute to the sense of sight what is the act of the memory and judgment.*

We have seen that the picture of an object is formed in the bottom of the eye. It was formerly sufficient to say, that the mind contemplates this image. We should say now, that this image is conveyed into the sensorium by the optic nerve. This is an hypothesis merely; and we have no more consciousness of the object being in the brain or sensorium than in any other part of the body: we may rather say, that the impression made on the organ, nerves, and brain, is followed by sensation, and that the intelligence is the joint operation of the whole.† Lastly, the metaphysician calls our sensations the signs of external objects; because the object itself is not presented to the mind, nor is there an actual resemblance betwixt the object and the sensation of it, but merely a connection established by nature, as certain features are natural signs of anger; or by art, as articulate sounds are the signs of our thoughts and purposes.

We are now naturally led to the consideration of some points, the full comprehension of which require the knowledge both of anatomy and of the principles of optics.

PARALLEL MOTION OF THE EYES.

The axis of the eye is a line drawn through the middle of the pupil and of the crystalline lens, and which, consequently, falls upon the middle of the retina. The axes of the eyes, it is evident, are not always parallel; for when both eyes are directed to a near object, the axes of the eyes meet in that object; but when we direct the eyes to the objects in the heavens, they may be considered as perfectly parallel in their axis, though, perhaps, not then mathematically so. To an observer,

* See Dr. Jurin on Mr. Molyneux's problem, Smith's Append. p. 27.

† Euclid, and others of the ancients, contended that vision was occasioned by the emission of rays from the eye to the object. He thought it more natural to suppose, that an animate substance gave out an emanation, than that the inanimate body did. In 1560, the opinion was confirmed that the rays entered the eye.—The sensation was not always believed to be in the retina: it was by some believed that part of the sensation was to be attributed to the crystalline. Kepler, in 1600, showed, geometrically, how the rays were refracted through all the humours of the eye so as to form a distinct picture on the retina; and also he showed the effect of glasses on the eyes. See further, regarding the opinions of the ancients, Boerhaave, Prælect. Acad. tom. iv. p. 282.

the eyes seem always moving in parallel directions; but Nature has given us the power of varying them so, that we can direct them to the same point, whether remote or near. This, however, is in some measure acquired by custom, and lost by disuse. A child has much difficulty in altering the distance of its eyes, which is the occasion of the vacancy of its stare; and we observe that a patient who has long lost one eye is incapable of directing the axis of the blind eye without looking with the other, and, even then, the blind organ does not follow the other with that perfect accuracy which exercise gives when both eyes are sound. By practice and straining, the axes of the eyes may be further altered from the natural parallelism. A child born blind turns its eyes in every possible direction, as it does its hands, without concert; but when the vision is perfect, there is a power which directs the eyes and leads to parallelism.

There is a particular sensible spot in the retina, which makes it necessary to distinct vision that this spot shall receive the concentrating rays of light; and the natural constitution of the eyes is such, that this spot in one eye shall have a relation to that of the other: that the axis of both should be accurately in the middle of the eye-ball, the child very soon acquires the power of directing the eyes with a simultaneous and corresponding effort.

By voluntary squinting or depressing one of the eyes with the finger, objects appear double, because the optic axis is changed in the distorted or depressed eye, and the picture is no longer painted on corresponding points of both retinæ. This simple experiment leads to consider what is the constitution and correspondence of the eyes, that, when each has the picture of the object impressed upon it, we should only see it single if the eyes are sound and perfect.

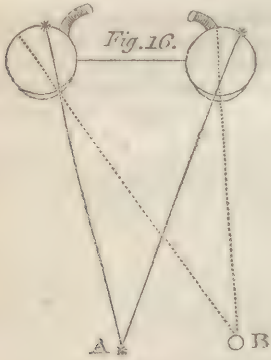


Fig. 16.

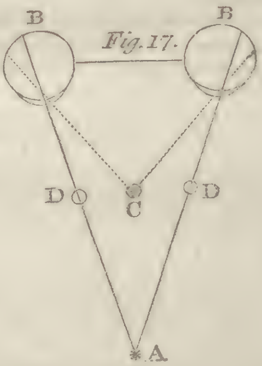


Fig. 17.

For example: the object A is exactly in the centre of the axis of both eyes, consequently, it is distinctly seen; and it appears single, because the rays from it strike upon the points of the retina opposite to the pupils in both eyes. Those points have a correspondence; and the object, instead of appearing double, is only strengthened in the liveliness of the image. Again, the object B will be seen fainter, but single, and correct in every respect. It will appear fainter because there is only one spot in

each eye which possesses the degree of sensibility necessary to perfect vision; and it will appear single, the rays proceeding from it having exactly the same relation to the centre of the retina in both eyes. Though they do not fall on the centre of the retina, they fall on the same side of the centre in both eyes. But if the eyes are made to fix steadfastly on an object, and if another object should be placed before the eyes within the angle which the axis of the two eyes make with the first object, it will be seen double, because the points of the retina, struck by the rays proceeding from the nearer object, do not correspond in their relation to the central point of the retina. Thus, the eyes B B, having their axis directed to A, will see the object C double somewhere near the outline D D. Because the line of the direction of the rays from that body C does not strike the retina in the same relation to the axis A B in both eyes. Upon this principle, we may easily explain why objects which are much nearer the eyes, or much more distant from them than that to which the two eyes are directed, appear double. Thus, if a candle is placed at the distance of ten feet, and I hold my finger at arm's length between my eyes and the candle, when I look at the candle, I see my finger double; and, when I look at my finger, I see the candle double. This double vision occurs to us all frequently; but, unless we make the experiment purposely, we do not attend to it. Many other instances of the harmony, and of the want of it, in the eyes, particularly the reverse of what these diagrams show, may be easily produced, viz. the seeing two objects single; for, if we look at a halfpenny and a shilling, placed each at the extremity of two tubes, one exactly in the axis of one eye, and the other in the axis of the other eye, we shall see but one piece of coin, and of a colour neither like the shilling nor like the halfpenny, but intermediate, as if the one were spread over the other.

This relation and sympathy between the corresponding points of the two eyes is, therefore, to be considered as a general fact, viz. that pictures of objects, falling upon corresponding points of the two retinas, present the same appearance to the mind as if they had both fallen upon the same point of one retina; and pictures upon points of the two retinas which do not correspond, and which proceed from one object, present to the mind the same apparent distance and position of two objects, as if one of those pictures were carried to the point corresponding with it in the other retina.

Several animals, we see, direct their eyes by very different laws from those which govern the motion of ours: but we are not to reason upon their sensations by the laws of vision of the human eyes: we must take it as a principle, that Nature has been bountiful to them also; and that the result of organisation in their eyes is perfect vision.

In birds (if we except the owl) the eyes diverge, and are directed to opposite sides. As the owl seeks his prey in the night, it may be necessary to the distinctness of his vision in weak light, that both eyes be directed to the object. Most fishes have their eyes directed laterally, though there are exceptions; as those fishes which are flat, and swim at the bottom, have their eyes directed upward. In many insects, the surface of the eye has no resemblance to the cornea of viviparous animals; but, when examined with the microscope, it is seen to consist of a number of tubercles, each of which is as a distinct eye. In others, the

eye is removed to the extremity of the movable tenaculæ. Very large animals, as the whale, elephant, rhinoceros, hippopotamus, have, in proportion to their bodies, very small eyes: so have the animals which live much under ground; and, in general, a large eye is a sign of the animal being able to see in obscure light, because there is proportionably a greater number of rays admitted into the eye. For the same reason fishes have a peculiarly large eye and dilatable pupil, because the water is a more obscure medium, and, from the occasional roughness of its surface much darkened and variable.

We must conclude, that in these varieties of the eyes, where there is a difference in number, position, and natural motion, there are different laws of vision adapted to these peculiarities and the exigencies of the animals.

If we are to judge from analogy, we may suppose, that in many animals there is no correspondence between points of the two retinas, or it is of a different kind from ours. In those which have immovable eyes, the centre of the two retinas will not correspond so as to give the idea of one object, but of distinct objects, and in their respective places; and, indeed, I conceive that in such the offices of the eye must be circumscribed: they will, perhaps, only distinguish degrees of light; and in such as turn their eyes in all directions, independently of each other, they would seem to possess a perception of the direction in which they move them, as we have of the motion of our arms. This consideration leads to a very curious subject.

SQUINTING.

The student cannot feel satisfied on the subject of the motions of the eyes, unless he understands this very common defect.

In the first place, we must observe, that there is a complaint, where, the muscles of the eye being primarily affected, the eyes are distorted. The images then fall on parts of the retina which have no correspondence, and the effect for the time is double vision. Afterwards there is single vision, without amendment of the distortion, but merely from the weaker impression on one eye being neglected. But this is not the very common case of squinting, where, with very evident obliquity of the eyes, there is single vision from the beginning. This common case of squinting, I apprehend, could not be understood whilst there was a neglect of the classification of the muscles of the eyes and an ignorance of their distinct offices.

It now appears, that the *recti* muscles of the eye-ball are in activity during attention to the impression on the retina; but that when that attention is withdrawn, the *recti* muscles are relieved, and the eye-ball is given up to the influence of the oblique muscles. This takes place in sleep, in fainting, and intoxication. When the nerve is deficient in one eye, and the sensibility less than in the other, the *recti* muscles are unexerted; the *obliqui* preponderate; and the state of equilibrium betwixt the two *obliqui* is when the eye-ball is turned, and the pupil presented upwards and inwards. Thus we perceive that by founding on a just view of the anatomy the whole train of facts connected with this curious subject accord, and the explanation of squinting is simple. Whereas,

before it was necessary to take a great deal for granted, and to suppose an *effort* of the muscles of the weak eye necessary to draw it out of the way of the other one; it being presumed that a weaker impression, in addition to a full and natural one, must be an injury to vision. We have seen, that there is a point in both retinas more acutely sensible to the impression of light and the image of objects, than any other part of all its concave surface. In a sound eye, this point is immediately opposite to the pupil. There is a coincidence betwixt this point and the axis of the eye; and when we look to an object, its image strikes this point of the retina.* If the greater sensibility of the nerve should lie in its proper place, and some cause should produce such an action of the muscles and distortion of the eye as we see in a squint, then the image will be double; for it no longer falls on corresponding points of the retina of each eye, and separate images are conveyed to the brain. If, however, this distortion continues, the single vision is gradually restored. Is there, then, in this case, produced a new correspondence betwixt points of the retina which were before discordant? We find that this is not the case, by a very simple experiment.—In a person who squints, one of the eyes is directed to the object and the other appears to be turned from it: if the sound eye be shut, and the person be directed to look to an object with the other, it is directed to it with the proper and natural axis. Now this shows us that the sensibility of the proper spot in the bottom of the eye is not altogether lost. But most people who squint have a defect of vision in the distorted eye, while the eye directed to the object has its natural sensibility to light. Now the mind does not attend easily to two impressions, the one being weaker than the other: in a short time the weaker impression is entirely neglected, and the stronger only is perceived. — So in squinting, the impression on the weak eye in a short time ceases to be attended to, the strong and vivid impression is alone perceived, and single vision is the consequence; while the eye, thus naturally excited, has the due degree of energy and activity of the recti, or voluntary muscles, but the other eye has no impression, and no such excitement as the natural stimulus on the retina affords to the recti muscles, and therefore it is drawn into that position which is its state of rest; the eye is as if asleep.

What is very extraordinary in squinting, is the correspondence in the muscles of the eye, notwithstanding the great distortion of the eye-ball; for, when both eyes are open, as the sound eye turns in all variety of directions to the surrounding objects, the other eye still follows it, but preserves its distance, so as in a manner to avoid all interference. But this is explained on the view stated. There is a preponderance of the oblique muscles over the recti, by which the eye is turned from the true line of the axis, without being altogether withdrawn from the influence of voluntary effort. Blows on the head, drinking and smoking, and a variety of irritations, occasion convulsions and distortion of the eyes, but they, at the same time, cause double vision. This is evidently produced by the affection of the muscles moving the eye-ball (since a change of the sensibility of the retina could not give occasion to distortion during a state

* This was M. de la Hire's opinion. — He had an idea also that squinting was produced by the obliquity of the object. Both of these opinions are refuted by Dr. Jurin.

of insensibility); we may, therefore, conclude, that squinting is sometimes the consequence of irregular action of the muscles, independent of the condition of the retina.*

We can distort our eyes by an unnatural effort, but we cannot squint, that is to say, we can bring our eyes into such a forced situation that we cannot see any thing distinctly; but we cannot keep one eye distinctly upon an object, and turn the other from it. — Such a position of the eyes, at least, (and which is exactly that of those who squint unintentionally,) I cannot by any means accomplish.† This shows the strict correspondence betwixt the moving muscles of the eye-balls. By this experiment, we shall find the difficulty of that method of correcting the squint proposed by Dr. Jurin, or of commanding motions of the eyes different from those which have been bestowed by nature, or acquired by habit. But habit I believe to be much more seldom the origin of squinting than is generally supposed. It is said, by Dr. Reid and others, that we see young people, in their frolics, learn to squint, making their eyes either converge or diverge when they will to a very considerable degree: why should it be more difficult for a squinting person to learn to look straight when he pleases? The reason of the greater difficulty is obvious, — that in making the eyes converge or diverge the will is acting upon both eyes equally; but to distort one eye inward or outward, and at the same time to keep the other fixed, is to me like an absolute impossibility. But the reason of the difficulty of correcting squinting is, as I have stated, that the voluntary muscles of the eye are deficient in their natural stimulus, which is the exercise and enjoyment of the sense of vision.

A frequent effect of the weakness left by long fevers in children is a squint which gradually goes off as the strength is restored. It is observed, also, that squinting and double vision are, in some fevers, a concomitant with delirium and phrenitis. This symptom proceeds, in all likelihood, from an unequal tension of the muscles of the eye-ball. The double vision is the effect of discordance in the action of the muscles.‡

* In Smith's Optics, there is a case of squinting and double vision occasioned by a blow. In Buffon's Dissertation, in the Acad. Roy. des. Sc 1743, squinting after long continued pain of the head. In the Mem. Roy. de l'Acad. des Sc. 1718, Hist. p. 29., there is a curious instance of false vision. I find also quoted several cases of strabismus from sudden fright, in *Ephem. Germ. cent.* 3. & 4. *obs.* 152. *p.* 349. Ib. dec. 3. an. 8. & 11. ob. 57. d. 114. Ib. dec. 3. an. 9. & 10. obs. 67. "Novi Juvenem paralysi obnoxium, cui cum cæteris oculi sinistri musculis relaxatis, *adducens* fortius contraheretur propter oculum ita distortum objectum quodcunque duplex apparebat, nec quod verum esset distinguere potest." *Willis de anima Brut. P. Physiol.* p. 77. An instance of the loss of corresponding motions of the eyes, and strange illusions of sight. See in the Enquiry into the Nature of Mental Derangement by Dr. Crichton, vol. i. p. 147.

† It is said that astronomers, who are much used to attend only to the impressions of one eye, are sometimes able to squint at pleasure. See Mr. Home, Phil. Trans. 1797, p. 17.

‡ This has been more lately explained by the author in a distinct dissertation, and he hopes to pursue the subject further. See *Philos. Trans.*

OF THE EAR.

OF SOUND, AND OF THE EAR IN GENERAL.

Sound is the effect of impression on the auditory nerve, by which a corresponding change is produced in the brain, and the perception of sound excited. It may be produced by the vibration and motion of the air, but not without the intervention of solids. The human voice, for example, does not depend merely on the percussion of the air, but on that vibration, as combined with the tension and consequent vibration of the glottis, excited by the current of air. However, the vibrations which produce sound are not those which are visible or are felt by the finger; sound depends on a more minute motion of the particles of bodies, and is only cognizable by the appropriate organ, the ear.

There is no body impervious to sound, or, in other words, incapable of transmitting the vibration. That sound is communicated through the medium of the air, we know from the circumstance, that a bell, when struck in a vacuum, gives out no sound; and again, from this, that the condensed state of the atmosphere affords an easier communication of sound, and conveys it to a greater distance. The velocity of the impression transmitted by the common air is computed at 1130 feet in a second; and sound, when obstructed in its direct motion, is reflected with a velocity equal to that with which it strikes the solid body by which its progress is interrupted.

That water conveys the vibrations producing sound has been proved by experiment. It was once the saying of naturalists, that to suppose fishes to have the organ of hearing, would be to conceive that an organ were bestowed upon them without a possibility of its being of use. But we are assured of the fact, that, on the tinkling of a bell, fishes come to be fed*; and it was the custom for the fishermen on the coast of Britany to force the fish into their nets by the beating of drums†, as our islanders are at present accustomed to do when the larger fish get entangled amongst the rocks. We are told, that in China they use a gong for the same purpose. These facts were once of importance, though more accurate observation has now made them superfluous. The Abbé Nollet took much pains to decide the question, whether water was a medium for sound. After considerable preparation, and acquiring a dexterous management of himself in the water (for which he takes great merit to himself), he found that he could hear under water the sound of the human voice, and even distinguish conversation and music. The

* Boyle.

† M. l'Abbé Nollet, Acad. R. des Sciences. Naturalists were very incredulous of the effects said to be produced by music on lobsters. Some may be so still; but there is no doubt that they possess the organ of hearing. See *Scarpa Disquisitiones Anatomicæ* de Auditu in Insectis, &c.

human ear being an organ imperfectly adapted to this medium of sound, these experiments do not inform us of the relative powers of air and water in the transmission of sound. But another experiment of the Abbé Nollet proves, what indeed to me is sufficiently evident, from the structure of the ear of fishes, viz. that the water transmits a much stronger vibration than the air. When he sunk under water and struck together two stones which he held in his hands, it gave a shock to his ear which was insupportable, and which was felt on all the surface of his body, like that sensation which is produced when a solid body held in the teeth is struck by another solid body.* He observed, in other experiments, that the more sonorous the bodies struck were, the less vivid was the impression; by which it would appear, that water, though it conveys an impression more strongly to the ear than the air, is not equally adapted to the resonance and variety of tone. Indeed, this is a natural consequence of the water, a fluid of greater density, being in close contact with the sounding body, and suppressing its vibration. In these facts, we shall find the explanation of some peculiarities in the structure of the ears of fishes.

Thus, we see, that the vibration of a solid body is continued through the air, and through water, until reaching the organ of hearing, it produces the sensation of sound. Sound, it will be evident, is also communicated through solids. When we put the ear to one end of a log of wood of thirty feet in length, and strike upon the other, we are sensible of the impression; and when a solid body applied to the bones of the head, or to the teeth, is struck, we are sensible of the noise†; and this is felt even by those who are deaf to impressions conveyed through the air: indeed it is partly in this way that we are to judge whether deafness may be cured by operation, as depending upon some injury of the mechanism of the organ, or whether it be an incurable affection of the nerve, or brain itself. If the sound be perceptible when conveyed through the teeth, or when a watch, for example, is pressed upon the bone behind the outer ear, we are assured that the internal organ is unaffected; and upon enquiring farther into the case, we may find that the deafness proceeds from some disease of the outer tube of the ear, or of that tube which leads into the throat, and that it can be remedied.

GENERAL VIEW OF THE VARIETIES IN THE EARS OF ANIMALS.‡

There is in the scale of animals a regular gradation in the perfection of the organ of hearing. But, in the human ear, we find united all the variety of apparatus for communicating the vibration to the internal organ, and along with this the most extensive distribution of nerves in the labyrinth, or inmost division of the ear, to receive that impression.

* These experiments were repeated by Dr. Monro. See his Book of Fishes.
† Perhaps we cannot call this sound.
‡ In the following short account of the comparative anatomy of the ear, although I have taken every assistance in my power from books, I have described the structure, in all the examples, from my own dissections and observations.

The ultimate cause of this more complex structure is the greater power with which man is endowed, of receiving through the ear various impressions of simple sounds; language, music, and various modifications of the sense, of which the lower animals are probably incapable.

As, in treating of the anatomy of the eye, we do not attempt to investigate the manner in which light acts upon the retina, in producing the sensation of colours, but endeavour merely to explain the structure of the eye; to show how the coats support and nourish the humours; how the humours serve to concentrate the rays of light, and assist their impulse upon the retina: so, in the same manner, in explaining the structure of the ear, we need not investigate the philosophy of sound, nor the nature of those impressions which are made by it on the sensorium through the nerves; our views are limited to the structure of the ear: we have to observe the mechanism by which the strength of vibrations is increased and conveyed inward to the seat of the sense, and the manner in which the nerve is expanded to receive so delicate an impression.

The method of studying this subject, which is at once the most instructive and the most amusing, is to trace the various gradations in the perfection of the organ, through the several classes of animals. It is chiefly by comparing the structure of the viscera, and the organs of sense in animals and in man, that comparative anatomy is useful in elucidating the animal economy. For example, in the stigmata and air-vessels of insects and worms; in the gills of fishes; in the simple cellular structure of the lungs of amphibia; in the more complicated structure of the lungs of birds; we observe one essential requisite through the whole gradation, viz. the exposure of the circulating fluids to the action of the air. And in this variety of conformation, we see the same organ so modified as to correspond with the habits and necessities of the different classes of animals. In the same manner, with regard to the circulating system, we are taught the explanation of the double heart in the human body, by tracing the variety of structure through the several classes of animals; from the simple tube circulating the fluids of insects, the single ventricle of fishes and reptiles, the double auricle and perforated ventricle of amphibia, up to the perfect heart of the warm-blooded animal. The organs of generation, and the economy of the fœtus in utero, are, in the same degree, capable of illustration from comparative anatomy. But most especially in the structure of the ear, is there much scope for this kind of investigation. We find such varieties in the ear of reptiles, fishes, birds, and quadrupeds, as lead us, by gradual steps, from the simpler to the more complex structure.

The simplest form of the organ of hearing is that in which we find a little sac of fluid, and on the inside of the sac the pulp of a nerve expanded. If an animal, having such an organ, breathe air, a membrane closes this sacculus on the fore part; and, by means of this membrane, the vibrations of the air are communicated to the expansion of the nerve through the fluid of the sac. But if the animal inhabits the water only, it has no such membrane to receive the impression; the organ is incased in bone or cartilage, and instead of the exterior membrane, some small

bone or hard concreted matter is found suspended in the fluid of the sac nerve. The sound, passing through the waters, is, in such case, conveyed to the organ not by any particular opening, but through the bones of the head; and this concrete substance, partaking of the tremulous motion, communicates an undulation to the fluid, and through it an impression to the nerve.*

For example, in the CRAB and LOBSTER, we find a prominent bony papilla or shell, which is perforated; a membrane is extended across the perforation; and behind this membrane there is a fluid, in which the nerve is expanded, and which receives the impulse conveyed to the membrane. In the CUTTLE-FISH there is no external opening; there is merely a little sac under the thick integuments: this sac has in it a small concretion or bone for receiving the vibration, which, in this animal, is conveyed by a more general impression upon the head than in the instances last mentioned; and the vibration of this loosely-poised bone or concrete, seems equal to the provision of the membrane which, in the crab, closes up the external opening in the perforated shell.

In FISHES, there is a considerable variety of structure. Those which remain perpetually under water have not the outer membrane, nor any apparatus for strengthening the first-received undulations of sound. But such as lie basking on the surface of the water, and breathe through lungs, have an external opening—a canal leading to the membrane, and behind the membrane, bones to convey the vibration to the internal parts, and these internal parts are nearly as perfect as in terrestrial animals.

In neither of the species of fishes, the cartilaginous nor spinous fishes, is there a proper external opening, as in animals breathing air. They receive the impulse from the water, upon the integuments and bones of the head; but within the head, and in the seat of the sense, they have a most beautiful apparatus for receiving and conveying those general vibrations to the expanded nerve. There is in every ear, adapted to hearing under water, a bone or concretion, placed so as to vacillate easily, and which is destined to agitate the fluid, in which it is suspended, with a stronger vibration than could be produced merely by a general impulse. Besides this provision in fishes, there is a very elegant structure for still further increasing the surface destined to receive the impulse, and for exposing to that impulse or vibration a larger proportion of the expanded nerve. It consists of three semicircular tubes, which penetrate widely within the bones of the head. They are filled with a fluid, and have in their extremities a division of the nerve which is moved or otherwise affected by the vibration of the fluids contained within the tubes.

There is a slight variety, however, in the ear of cartilaginous fishes. In the head of the SKATE, for example, there is under the skin, at the back of the head, a membrane extended across a pretty regular opening. This, however, is not considered as the opening of the ear; but a passage, like a mucous duct, which is beside it, has given occasion to a controversy between Professors Scarpa and Monro; and it may not be out of place to enquire a little into this disputed point.

* It is conceived by some that the antennæ of insects convey to them the vibration of bodies, and that they may be considered as an imperfect variety of this organ. They may receive an impression from the vibration of the air; but as their nerves are nerves of touch, it cannot be sound which they experience.

We have seen that water conveys the sound of vibrating bodies with a shock almost intolerable to the ear, and with a particular and distinct sensation over the whole body. We see, also, that, in the greater number of fishes, there is confessedly no external opening, the whole organ is placed under the squamous bones of the head. Yet the cartilaginous fishes, which are supposed to have an external ear, swim in the same element, and are in no essential point peculiar in their habits. And we should receive with caution the account of any peculiarity in the organ of hearing of one class of fishes, which is not common to all inhabiting the same fluid. Such animals as occasionally pass from the water into the air must have a membrane capable of vibrating in the air; but, even in them, it is expanded under the common integuments, and protected by them. Were it otherwise, when the creature plunged into the water, it would be assailed with that noise (confounding all regular sounds), of which man is sensible when he plunges under water. It appears opposite to the general law of nature to suppose any species of fish to have that delicate membrane which is intended to convey atmospheric sounds; while other creatures living in the water have no such provision.

When we come to examine the ear of the skate, we find, that what Dr. Monro conceives to be the OUTWARD ear of the fish*, is really, as represented by Scarpa, a mucous duct merely†; which does not lead into the sacculi of the vestibule and semicircular canals, as appeared to Dr. Monro; and that to suppose this, would be to acknowledge the free access of air and water to the immediate seat of the organ, and to the soft pulp of the auditory nerve, a thing not to be believed.‡ To me it appears, that this narrow duct cannot be considered as the external ear; because we find in the skate a proper membrane under the thin integuments for transmitting the sound quite unconnected with the duct; and, upon following this mucous duct, we find it taking a circuitous course, and filled with a strong gelatinous matter: it is every where narrow, and filled with a glutinous secretion. It has no membrane stretched across it, and bears no resemblance to the external ear of any other animal.

We may conclude, then, that fishes have no external opening like terrestrial animals; that, instead of this outward provision, they have the movable bone within the organ. Although the cartilaginous fishes have a membrane extended over part of the organ, which, in the spinous fishes, is completely surrounded with bone, it is not to be considered as capable of the tremulous motions of the membrana tympani of terrestrial

* "In the upper and back part of the head of a skate and in a large fish weighing 150 pounds, at the distance nearly of one inch from the articulation of the head, with the first vertebra of the neck or atlas, two orifices capable of admitting small-sized stocking wires, at the distance of about an inch and a quarter from each other, surrounded with a firm membraneous ring, may be observed. These are the beginnings of the Meatus Auditorii Externi." Treatise on the Ear, p. 208.

† Scarpa, speaking of this opinion of Dr. Monro, says, "Qua in re vehementer sibi hallucinatus est, ostia nimirum ductuum mucosorum, ut manifestum est, pro auris meatibus accipiens, Etenim omnino nullum est in cartilagineis piscibus ostium auditus extus adapertum, membranaque *fenestræ ovalis* sub communi integumento recondita jacet et cooperta."

‡ Quod et absurdum est et a rei veritate quam maxime alienum." Vid. *Anatomicæ Disquisitiones de auditu et olfactu, auctore* A. Scarpa.

animals, but may be considered as analogous to the membrana fenestræ ovalis; and, since it lies deep under the integuments, we have no reason to believe that sound is transmitted to the organ of hearing in fishes, any otherwise than through the general vibration of the head.

The organ of hearing in amphibious animals demonstrates to us a difference in the manner in which the sensation is received: for they have both the outer membrane to receive the vibration of the air and a mechanism of small bones to convey this motion into the seat of the sense; and they have, besides, within the ear itself, a chalky concretion; a provision plainly intended for propagating the motion communicated through the water.

In serpents, birds, and quadrupeds, we shall hereafter trace the various gradations in the perfection of this organ. We shall find, that, as the animal rises in the scale, the cavities and tubes of the ear are extended and varied in their form. Now, I conceive that, while the multiplied forms of the tubes and sphericles of the internal ear afford a more expanded and susceptible surface for receiving impressions, the consonant forms of the parts enable them to receive a stronger vibration, and a more perfect and modified sound.

A chord of a musical instrument will vibrate when another in exact unison with it is struck. The vibration communicated to the air is such as is adapted to the tension of the symphonic chord; and no other percussion of the air, however violent, will cause it to sound. Again, the air passing through a tube of certain dimensions, will not communicate to it a motion, nor call forth its sound, while the air, passing in equal quantity through a tube of one degree of difference, will rise into a full note. What holds true in regard to the unison of chords is also true of cylinders, or even of the walls of a passage or room — a certain note will cause the resonance of the passage or room, as a certain vibration will call forth the sound of the tube of an organ; because it is in all these instances necessary that the impulse be adapted to the position of the surfaces and their powers of reverberation.

These few facts illustrate what I mean, by saying, that the various forms of the internal ear of animals, as they advance in the scale, give additional powers to their organ. In the first example of the simple ear, where a bone vibrates on the expanded nerve, I should conceive that the sensations were in consequence of this simple percussion capable of little variety; but in animals where, besides this simpler mechanism, there are semicircular canals, and more especially in those animals which have still a farther complication of the forms of the ear, certain sounds will be peculiarly felt in each of these several cavities and convolutions; and while the sensation is becoming more distinct, by the perfection of the organ, it admits also of a greater variety of sounds or notes: so that a certain state of vibration will affect the semicircular canals (one or all of them), and produce the sensation of sound, which would not at all affect the vibration of the simple lapilli lying in their sac.

DESCRIPTION OF THE ORGAN OF HEARING IN PARTICULAR ANIMALS.

IN THE LOBSTER AND CRAB.

In these animals, the structure of the ear is very simple; but it appears to me that Professor Scarpa, in his description, has imagined the organ to be more simple than it is in nature.

In the LOBSTER, there projects from near the root of the great antenna an osseous papilla of a peculiarly hard and friable nature. In the point of this papilla we observe a foramen, and a membrane stretched over it. This is the seat of the organ of hearing. It is described as containing a sac of a pellucid fluid, which adheres to the membrane, while the auditory nerve is expanded upon the lower surface of the sac. Now, the lobster, being an animal which can live on land as well as in water, Scarpa gives this as an instance of a structure calculated to receive the sensation of sound equally well from the water or from the atmosphere. But, to me, it does not appear to be so exceedingly simple; while there is evidently a provision for the reception of the vibration communicated through the water, though it does not indeed strictly resemble that which is commonly found in the ears of fishes. There is suspended behind the sacculus, and in contact with the nerve, a small triangular bone, which, when pulled away*, is found to hinge upon a delicate cartilage. This bone seems intended, by its being thus suspended in the neighbourhood of the PULP OF THE AUDITORY NERVE, for impressing upon that nerve the vibration from the water. The lobster, then, has, like the amphibious animals, a double provision for receiving the communication of sound either from the water or from the air.†

The ear of the CRAB differs from that of the lobster in this, that, under the projection, there is a movable case of bone, to which we see a small antenna attached. Within this is the organ of hearing; and there is here an internal provision for the transmission of sound to the auditory nerve, which consists simply in a few circumgyrations of a pellucid and flexible cartilage: an inspissated fluid surrounds this cartilage, while the auditory nerve is expanded behind it.

OF THE EAR OF FISHES.—In the heads of fishes there is a cavity separated by a thin vascular membrane from that which contains the brain. Within this cavity there is a sacculus distended with a fluid, and containing a small bone‡; on the inside of this bag (which is called the sacculus lapillorum) a great proportion of the auditory nerve is expanded. In the cartilaginous fishes there are three lapilli§ contained in their proper capsules, and surrounded with a gelatinous matter||, each of the

* See fig. 2.

† From the mucous-like transparency of the nerve in the lobster, it is difficult to ascertain its exact relation to this bone.

‡ See plate, fig. 3.

§ In many of the spinous or squamous fishes there is only one. In cartilaginous fishes, these bodies are not like bone, but like soft chalk. In the spinous fishes, on the other hand, they are of the shape of the head of a spear, and hard like stone.

|| The gelatinous matter is rather before the bones, and distending the little sacculi

lapilli having its appropriated division of the acoustic or auditory nerve distributed upon it in a beautiful net-work.

This cavity in the head of fishes resembles the centre of the labyrinth in the human ear, which is called the vestibule. Within the vestibule there is a limpid fluid, intersected every where by a delicate and transparent cellular membrane; and the parts within the vestibule are supported in their place by this tissue, which is similar to that which supports the brain in fishes.

Besides this central part of the organ in fishes, there are departing from the vestibule three semicircular cartilaginous canals, within which are extended membranous canals. These membranous tubes contain a fluid distinct from that contained in the common cavity of the vestibule, nor have they any communication with the sacculi, which contain the lapilli, although they are in contact with them.* These cartilaginous canals are of a cylindrical form, and, being as transparent as the fluid with which they are surrounded, are not readily distinguished in dissection. Each of the cartilaginous canals is dilated at one of its extremities into a little belly, which is called the ampulla.

The auditory nerve in cartilaginous fishes† is first divided into two fasciculi, which are again subdivided into lesser nerves. These go to the three sacculi lapillorum, and to the ampullulæ of the semicircular canals. Before the division of the nerve which goes to the sacculus pierces it, it forms a singular and intricate net-work of filaments. The branch to the ampullula is raised on a partition which stands across as if to receive the undulations of the fluid coming along the tube.

In the spinous fishes, the three semicircular canals unite in a common belly; but in cartilaginous fishes the posterior semicircular canal is distinct from the others.

In fishes all the parts of the ear are filled with a matter of a gelatinous consistence, or viscid fluidity; and the whole sacculi and semicircular canals are surrounded with fluid. That jelly is the most susceptible of vibration, is evident when we fill a glass, and allow a body to fall into it; for then the delicate vibration is communicated to the finger on the outside of the glass, or by striking the glass, we may observe the tremulous motion of the jelly. The semicircular canals, containing such a fluid, are well adapted to receive the extensive vibrations communicated through the bones of the head, and to convey them to the nerve expanded in the ampullula.

From the simpler to the more perfect aquatic animals, we may trace several links of the chain by which nature advances towards the perfect structure of the ear. We return now to observe, in the first example of terrestrial animals, the most simple state of that part of the organ which receives the sensation; but while the structure of the internal organ is the most simple, the mechanism for receiving the vibration and conveying it to the internal ear is modified and adapted to the atmosphere.

* So Professor Scarpa asserts, in contradiction to others.

† The fifth pair of nerves in fish answers to the seventh in man; has the same division into the *portio mollis* and *dura*.

OF THE EAR IN REPTILES AND AMPHIBIOUS ANIMALS.

In REPTILES, which form the intermediate class of animals betwixt fishes and quadrupeds, the ear has also an intermediate structure: in some individuals of this class the ear resembles that of fishes, such as we have described; while, in others, it resembles more nearly the common structure of terrestrial animals.

In the salamandra aquatica, a variety of the lizard, there is a foramen ovale*, deep under the integuments. In this foramen there is a cartilage, in immediate contact with which there is a common sacculus lying in the cavity or vestibule; and in this little sac there is found a cretaceous matter; there are here, also, semicircular canals, with ampullulæ, and a common belly connecting them. In this animal, then, it is evident, the ear is similar in structure to that of the cartilaginous fishes.†

In the FROG, the outward apparatus is different, but the internal ear is simple. Under the skin of the side of the head, a little behind the prominent eye, we find a large circular opening, which tends inward in a funnel-like form; and from the upper part of the circle of this meatus we find a small elastic bone, or cartilage, suspended. This bone is in contact with the common integuments of the head, which are stretched over the little cavity. This first bone is placed at a right angle with a second bone, and both are lodged in a proper tympanum.‡ This second bone swells out towards its inner extremity, and is accurately applied to the foramen ovale. The foramen ovale opens into a cavity which we must call the vestibule, and which, in this creature, is peculiarly large in proportion to its size. This vestibule contains a sac, upon which the nerve is expanded; it contains also a chalky soft concretion, which is of a beautiful whiteness, and of a regular figure when first seen, but has no solidity. The vestibule here, as in all other animals, being the immediate seat of the sense, is filled with fluid.

In SERPENTS, the mechanism external to the seat of the organ is less complete than in the frog. From the scales behind the articulation of the bone which keeps the lower jaw extended, a little column of bone stretches inward and forward. This bone has its inner extremity enlarged to an oval figure, and is inserted into the foramen ovale. This creature has no membrana tympani, nor does it appear to have so good a substitute as the frog: the outer extremity of the bone seems rather attached to the lower jaw by a cartilaginous appendage and small ligament.§ Within the skull, serpents have the little sac, with the cretaceous matter and semicircular canals, united by a common belly.||

* This is the appropriate appellation of the opening, which leads from the outer cavity of the ear, or tympanum, into the seat of the proper organ where the nerve is expanded.

† It is said by naturalists, that the salamander never has been heard to utter a cry; and as dumbness is in general coupled with deafness, it is natural to suppose it has no ears. This is to consider the organ as subservient to conversation.

‡ This tympanum being a cavity containing air, has communication with the mouth by a tube, which we shall afterwards find called Eustachian tube. Several have erroneously described this animal as receiving sounds through the mouth.

§ See Scarpa, tab. v. fig. ix.

|| Serpents are affected by music: and they will raise and twist themselves with every variety of lively motion to the pipe and tabor.

In the TURTLE, we find a proper tympanum, and by lifting the scaly integuments from the side of the head a little above the articulation of the lower jaw, we open this cavity. Through this cavity there extends a very long and slender bone, which, upon the outer extremity, is attached by a little elastic brush of fibres to the cartilaginous plate under the integuments, while the inner extremity is enlarged, so as to apply accurately to the foramen, which opens into the vestibule; and a passage also opens from the cavity of the tympanum into the fauces. In this animal, as in all which we have classed under the present division, the internal ear consists of a central cavity, or vestibule, which contains a sac with fluid, and cretaceous matter, and of three semicircular canals connected by a common belly. This common belly of the semicircular canals has no communication with the sacculus vestibuli, which contains the cretaceous matter, further than as it lies in contact with it, and as they both lie surrounded by a fluid: they equally receive the impression of the little bony column, the extremity of which vibrates in the foramen ovale.

There being enumerated forty or more varieties of the LACERTA or LIZARD, many of these have very different habits. Some of them never pass into the water, but inhabit dry and dusty places. The lacerta agilis, or common green lizard, which is a native both of Europe and of India, is nimble, and basks, during the hot weather, on the trunks of old trees and on dry banks; but on hearing a noise it retreats quickly to its hole. It has the skin over the tympanum extremely thin, and such as to answer precisely the office of the membrane of the tympanum. So all the varieties of reptiles which, in their habits and delicacy of hearing, resemble terrestrial animals, have either the membrane of the tympanum or a skin so delicate as to produce the same effect; while those which inhabit the water have a rough integument, or a hard scale, drawn over the tympanum. Besides this, some have a small muscle attached to the bone, which runs across the tympanum: it is like the tensor tympani, and is another step towards the proper structure of the terrestrial ear.

OF THE EAR IN BIRDS.

Comparing the internal ear of birds with that of the animals which we have already described, we find a very important addition. We find here the internal ear (or labyrinth, as we may now call it,) consisting of three divisions: the vestibule, or middle cavity; the semicircular canals; and the cochlea; which last is an additional part, and one which we have not in the class of animals already described. Leading into these three cavities, there are two foramina; the FENESTRA ROTUNDA, and the FENESTRA OVALIS; and both these openings have a membrane stretched over them in the fresh state of the parts. The first, the fenestra ovalis, or foramen ovale, receives the ossiculus auditus, which is in birds like that which we have already described in reptiles.* This os-

* Sir E. Home, in his lecture on the muscularity of the membrana tympani (vid. Phil. Trans. A. 1800), says, in birds this membrane has no tensor muscle to vary its adjustments, but is always kept tense by the pressure of the end of the slender bone.

siculus connects the membrana tympani (which is here of a regular form) with the vestibule, and conveys the vibration of the atmosphere to it.

The semicircular canals are here also three in number, and are distinguished by the terms minor, major, and maximus; but as the major and minor coalesce at one of their extremities, and enter the vestibule together, the semicircular canals open into the vestibule by only five foramina in place of six. Each of the semicircular canals is dilated at one extremity into an elliptical form, while the other extremity is of the natural size of the diameter of the tube. These canals are formed of the hard shell of bone, and are surrounded with bone, having wider and more open cancelli.

In the dry state of the parts, we find a cord passing through the semicircular canals, which some have called the ZONULÆ NERVOSÆ. But these are the membranous canals, which are contained within the bony ones, dried and shrunk up. Within the bony cavities of the labyrinth, there is laid a pellucid membrane, which contains a fluid, has the nerves expanded upon it, and is the true vestibule and semicircular canals; while the bony case, which we have described, is merely the mould of these, and the support of their delicate texture.*

The COCHLEA, one of the three divisions of the labyrinth, is but imperfect in birds, when compared with that part of the organ in quadrupeds and in man. The cochlea in birds consists merely of two cylinders, formed of cartilage, which are united toward their further extremity. While the opposite extremities diverge, and while one of these cylinders opens into the vestibule, the other opens outward into the cavity of the tympanum.†

That which, more than any other circumstance, distinguishes the organ of birds from that of animals inhabiting the waters, is the want of the bone or stony concretion in the sacculus vestibuli.

OF THE HUMAN EAR.

THE anatomy of the human ear will naturally be considered under three heads: the external ear; the tympanum; and the labyrinth. The OUTWARD EAR requires no definition. From the outward ear there

This is a very imperfect account of the mechanism of the tympanum in birds. There are two bones, or one small bone with a cartilage, which lies along the membrana tympani. This elastic cartilage has two little tendons attached to it. Even the slender bone which stretches from the cartilage to the foramen ovale, the inner extremity of which is enlarged to fill up that hole, seems to have a small tendon inserted into it; but whether this be a muscular or ligamentous connection I am unable at present to say.

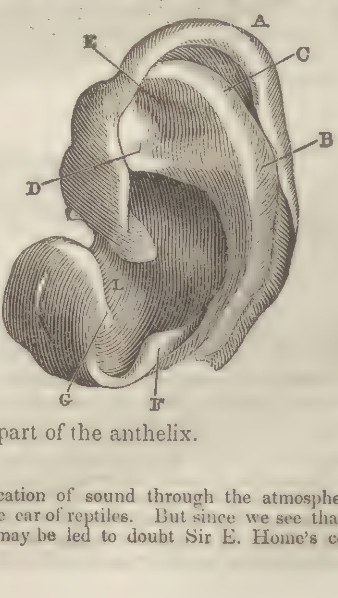
* On drawing out the sacculus vestibuli and semicircular canals from the bony part of the ear of a bird, I find the membranous semicircular canal to consist apparently of the same pellucid elastic matter with those of fishes.

† We find Sir E. Home saying that the cochlea is neither absolutely necessary to fit the organ to be impressed by sounds communicated through the air, nor to render it what is termed a musical ear; and that this is sufficiently proved by that part being wanting in birds, whose organ is particularly adapted to inarticulate sounds. That the

is a cartilaginous tube, which leads into the tympanum. The TYMPANUM is the cavity within which is placed that mechanism of bones and muscles which increases the strength of the vibration, and conveys it inwards to the labyrinth. The LABYRINTH is the general name of those intricate canals which contain the expanded nerve; it is the proper seat of the sense.

OF THE EXTERNAL EAR.

The EXTERNAL EAR is formed of elastic cartilages, covered with very thin integuments. The apparently irregular surfaces of the outer ear will be found, upon examination, to be so formed that the sinuosities lead gradually into each other, and finally terminate in the concha or immediate opening of the tube of the ear. By the constant motion of the external ear of quadrupeds, we see its importance to them both in collecting sound, and in judging of its direction. (We must not forget, however, in estimating the mobility of this apparatus, that the ears are used like the tail, to free them from flies.) In most men, the motion of the ear is lost, but some men still retain it; and this is very remarkable, that when the more internal mechanism of the ear is injured, and ceases to strengthen the sound before it conveys it inwards to the labyrinth, the external ear resumes the office to which it was originally adapted, and, by a degree of motion and erection, assists the hearing. In Europeans, the outward ear is in a great degree flattened to the head by the dress; but in eastern nations, and in ancient statues, we see the ears stand prominent, and bear a part in the symmetry and expression of the whole head. The muscles moving the cartilages, besides being intended to direct the ear, appear to have a more essential use in giving a due tension to the cartilages. These cartilages are surrounded with their peculiar pericondrium; but as to their vessels and nerves, it seems very superfluous to give a minute description of them here.



When the cartilages are dissected they appear thus:

A. The HELIX.—It is the outer margin, the edge of which is turned over, and forms the cavitas innominata.

B C D. The ANTHELIX.—It is very prominent; of a triangular shape; and within the outer rim or margin.

E. The SCAPHA, which is a depression or cavity on the anterior part of the anthelix.

cochlea is not necessary to the communication of sound through the atmosphere, we have seen from the examination of the ear of reptiles. But since we see that it forms part of the labyrinth in birds, we may be led to doubt Sir E. Home's conclusion.

F. The ANTITRAGUS.

G. The TRAGUS.—These are the two prominent points which approach each other, and form the margin of the great cavity of the ear.

L. The CONCHA, or great cavity of the ear, and which is the trumpet-like opening of the meatus auditorius externus. The few pale-coloured fibres which are found on the cartilages are scarcely to be recognised as muscles.*

The LOBE of the ear, or that part which hangs down and is pierced for the ear-ring in women and savages, consists of skin and cellular substance merely.

The MEATUS AUDITORIUS EXTERNUS is the tube which leads into the tympanum. This tube is partly bony and partly cartilaginous. The outer portion of the tube is cartilaginous, and about three quarters of an inch in length, and is divided by fissures. The deeper part of the tube is formed in the bone, as we find upon turning to the description of the temporal bone.

GLANDS OF THE PASSAGE.—The cuticle, covering the inside of the tube, is very fine, and there project from it many small hairs which stand across the passage. Under the skin there is a set of small glands, which pour their secretion into the tube, and are called the GLANDULÆ CERUMINOSÆ.† These glands, secreting the wax of the ear, have their little ducts opening betwixt the roots of the hairs; and this secretion with the hairs which stand across the passage guards the internal parts of the ear from insects. The whole passage, consisting of the canal of the temporal bone and the cartilaginous tube placed upon it, has an oblique direction. It first passes upward and forward, and then makes a slight curve to descend to the membrane of the tympanum.

This external tube of the ear, being of the nature of a secreting surface, and exposed to the air, is liable to inflammation. There follows a dryness of the passages, and then a more fluid secretion. If the inflammation of the tube should extend within the bones, then, like the affections of all parts surrounded with solid bone, the pain is extreme and the danger considerable: there is not only suppuration in the tympanum and destruction of the membrana tympani, but the disease may be still further communicated internally. Hildanus gives us an observation of the effects of a ball of glass dropt by accident into the ear, in which the inflammation was so extensive, and the pain so excruciating, that the whole side of the head, and even the arm and leg of that side were affected, in consequence of the brain partaking of the inflammation. Such things as peas and cherry-stones and pins are very apt to be put into the ear by children; and awkward attempts to extract the foreign body very often push it further in; and acrid fluids put into the ear to kill insects, have forced them deeper, with such an increase of pain as has thrown the patient into a condition little short of delirium. A defective or too profuse secretion from the glands of the tube will cause a

* See Valsalva and Santorini.

† "Hæ figuram obtinent variam; major tamen harum pars vel ad ovalem, vel ad sphæricam accedit colore tinguntur flavo ab humore in earum folliculis contento qui ob assiduam fibrarum carnearum reticularium pressionem, per cutis correspondentia foramina in meatus auditorii cavitatem transmittitur." Valsalva de aure humana, p. 10.

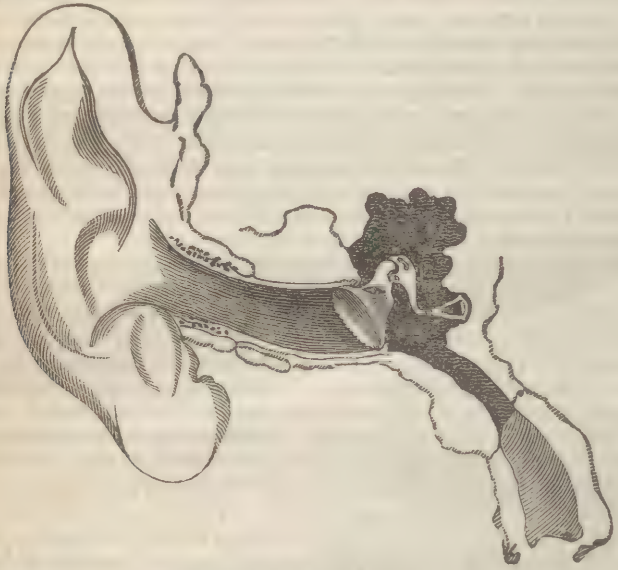
degree of deafness; and sometimes the wax is so indurated as to cause a very obstinate deafness.*

In the fœtus, the concha and meatus externus are narrow, and there is secreted a thick white stuff, which defends the membrane of the tympanum from the contact of the waters of the amnios. This, after birth, falls out in pieces along with the secretion of the wax; but, in some instances, it has remained, and become very hard.

OF THE TYMPANUM OR MIDDLE CAVITY OF THE EAR.

THE ANATOMY OF THE TYMPANUM.

In the fœtus, the cavity of the tympanum is superficial, compared with that of the adult; for what forms a tube in the latter, is in the former merely a ring, which is attached to the squamous portion of the temporal bone †: upon this circular bone the membrane of the tympanum is extended.



DESCRIPTION OF THE FIGURE.

The outer ear in outline. The tube of the ear is seen closed at the inner part by the membrane of the tympanum. The chain of bones in the tympanum is seen. And the Eustachian tube leading from the tympanum into the throat.

* See Valsalva, p. 10. "Talis surditalis a duodecim annis affligentis curatio." The older writers treat of the "Auditus læsio a surdibus aurium lapidescentibus." See *Bonetus*, and Jul. *Cassertus Placantinus*, "*De auditus organo*," *lib.* 1. *cap.* 20. p. 90. There is also mention made of an adventitious membrane closing up the passage, and stretched above the membrana tympani. This is produced by a foul secretion, and resembles that which stuffs up the passage in the fœtus. See Fabricius de Chirurg. operat. cap. de aur. Chirurg. Veslingius Anat. cap. 16. See Experiments on the Solvents of the Ear-wax by Dr. Haygarth, Med. Obs. and Enquiries, vol. iv. p. 198. He gives the preference to warm water over every other solvent.

† See plate 8. fig. 3.

The tympanum is a very irregular cavity, intermediate betwixt the membrane which is extended across the bottom of the external tube and the labyrinth or internal ear. It contains no fluid, as the labyrinth does; but is really a cavity, having a communication with the external air through a tube which leads into the fauces. The tympanum communicates also backwards with the cells of the mastoid process.* The inner extremity of the meatus externus forms a circle which is pretty regular, and upon which the membrane of the tympanum is extended. That part of the cavity of the tympanum, which is opposite to the termination of the meatus externus, is very irregular. It has in it the foramen rotundum and the foramen ovale; and betwixt these, there is an irregular bony tuberosity, called the tubercle, from which there stretch back some exceedingly small spiculæ of bone, which connect themselves with the margin of the irregular cavity of the mastoid process. On the opposite side of the cavity there is a small eminence, with a perforation in its centre, called the *Pyramid.*

The FORAMEN OVALE † is in the bottom of a deep sinus: it is not strictly of an oval form, but has its lower side straight, while the upper margin has the oval curve. This opening leads into the vestibule or central cavity of the labyrinth.

The FORAMEN ROTUNDUM is more irregular than the oval hole. It does not look directly forward, like it, but enters on the side of an irregular projection: it does not lead into the vestibule, but into one of the scalæ of the cochlea. In the recent state of the parts, the periosteum covering the surface of the cavity of the tympanum takes away something of its irregularity: we trace the internal periosteum backwards into the mastoidean cells.

The EUSTACHIAN TUBE ‡ extends forward from the cavity of the tympanum, and opens behind the palate.§ In the dry bones, the Eustachian tube is more like an accidental fissure, than a regular passage, essential to the economy of the ear. It appears thus irregular in the bones, from the tube being towards the back of the nose, composed of a movable cartilage covered with a soft membrane: as the tube approaches the opening behind the palate, it widens into a trumpet shape; and the extremity of the tube is governed by muscular fibres. Within the cavity of the tympanum, on the upper part of the Eustachian tube, there is a small canal, giving origin to the laxator tympani. This canal has been called *the spoon-like cavity.*

There can be no doubt that the Eustachian tube is designed for admitting the free access of air into the cavity of the tympanum, that, by preserving a due balance betwixt the atmosphere and the air contained within the ear, the motion of the membrane of the tympanum may be free. This, at least, we know, that, when the extremity of the Eustachian tube is closed, we suffer a temporary deafness, which can be ac-

* When Valsalva, in a case of ulceration and caries on the mastoid process, threw in his injections, he found them flowing out by the mouth; viz. by the Eustachian tube through the tympanum. See Val. de aure humana, p. 89.

† Fenestra ovalis.

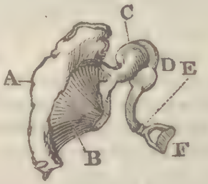
‡ Iter a palato ad aurem.

§ By some old writers, the Eustachian tube is called aqueduct, because they conceived that humours were evacuated from the tympanum by this passage.

counted for only by the confined air wanting a due degree of elasticity to allow the vibration of the membrane of the tympanum. I conceive it to be necessary, that the air in the tympanum be changed occasionally, which is accomplished by some actions of the throat and fauces, as swallowing, forcing a new body of air into the Eustachian tube. The extremity of the Eustachian tube, next to the throat, may be temporarily obstructed by the cynanche tonsillaris, which is frequently attended with pain, stretching from the throat to the ear; or it may be closed by inflammation and adhesion of its mouth, by adhesion of the soft palate to the back of the fauces, by polypus in the nose, reaching down into the fauces and compressing it, &c.*

OF THE MEMBRANA TYMPANI.

A. The bony margin of the outer auditory foramen.
B. Membrana tympani.
C. The malleus.
D. The incus.
E. Orbiculare.
F. The stapes.



The membrane of the tympanum is extended over the circular opening of the bottom of the meatus externus. It has a little of an oval shape, and lies over somewhat obliquely, so that its lower margin is further inward than the upper. Its use is, to convey the vibration or oscillation of the atmosphere, collected by the outer ear, inwards to the chain of bones in the tympanum. Although this membrane be tense, it is not stretched uniformly like the parchment of a drum, but is drawn into a funnel-like shape by the adhesion of the long process of the malleus to its centre. It consists of two layers of membrane, and has, naturally, no perforation in it; and the experiments of air, and the smoke of tobacco sent from the mouth through the ear, succeed only in those who have had the membrane of the tympanum partially ruptured or eroded by ulceration. This membrane is transparent; and when we look into the tube of the ear, and direct a strong light into it, we observe it to be of a shining tendinous appearance.

The inner lamina of the membrana tympani is very vascular. It has, indeed, been said to resemble the iris, both in its profusion of vessels, and in the manner of their distribution.† This is carrying the conceit of their analogy too far. I have observed an artery of a very large size (compared with the surface to be supplied) running by the side of the long process or handle of the malleus. In this course, it is giving out small

* The following case is from Valsalva:—"Quidam plebeius ulcus gerebat supra uvulam in sinistra parte, quod quidam eam, quam invaserat partem exeserat atque abstuleret sic, ut ulceris cavitas cum extremo sinistræ tubæ orificio communicaret. Igitur quoties homo mollem turundam remediis imbutam in ulceris cavitatem intrudebat: toties illico sinistrâ aure evadebat surdus, talisque permanebat toto ex tempore quo turunda in ulcere relinquebatur," p. 90.

† See Sir E. Home's lecture on the structure and use of the membrana tympani. Phil. Trans. Part I. 1800.

branches; and when the trunk arrives at the extreme point of the long process of the malleus, it divides into two branches, the extreme subdivisions of which run towards the margin of the membrane. This artery is, nevertheless, too small to require us particularly to avoid it in the puncturing of the membrane for deafness, produced by obstruction of the Eustachian tube.

The opinions regarding the muscularity of the membrane of the tympanum shall be reserved until we have considered the whole mechanism of the parts in the tympanum.

OF THE CHAIN OF BONES IN THE TYMPANUM.

The vibrations of the membrane of the tympanum are transmitted to the foramen ovale by four movable bones,—the malleus, incus, os orbiculare, and stapes. These bones are named from their shape, and the names assist in conveying an idea of their form. They are so united, by articulation and small ligaments, as to form an uninterrupted chain; and, while they transmit the vibration, their mechanism is such, that they strengthen the impulse. They have also small muscles attached to them, by which, it is probable, the whole apparatus has a power of adapting the degree of tension to the force of the impulse communicated to the membrane of the tympanum. I conceive that they increase the power of the ear for receiving the weaker sounds, and are, at the same time, a guard to the internal parts, from such violent shocks as might injure the nerve.


Malleus.


Incus.


Orbiculare.


Stapes.

How necessary it sometimes is to damp and suffocate, in some degree, piercing sounds, we must all be sensible; and in those who are habitually exposed to the sudden eruption of sound, the susceptibility of the nerve is injured, and they become very deaf. We have, in a late publication, an example of this in blacksmiths, in whom it is common to find a degree of deafness; and we find old artillery-men quite deaf, from the long practice of their profession.

The MALLEUS receives its name from a resemblance to a hammer or mallet: it is, in some degree, like a bludgeon; the great head stands obliquely off from the body of the bone (if such it may be called) like the head of the thigh-bone. Anatomists can scarcely be blamed, if, in describing the processes of this bone, they forget the body. I should consider that part as the body of the bone which stretches down from the circular margin of the tympanum, and is attached to the membrane, or what we should consider as the handle of the mallet. This part of the bone stands at an angle with the head and neck; tapers towards the extremity, and is a little curved down towards the membrane. From the larger end of the body of the bone there stands out an acute process; and from the neck attaching the bulbous head to the body of the bone

there stands out a very slender process, which is often broken off. The great head of the bone does not form a regular ball to be socketed in the body of the incus: there are irregularities in the contiguous surfaces of both the bones.*

The INCUS is the second bone of the chain: it receives its name from its resemblance to the blacksmith's anvil. It more resembles a molar tooth with two roots. On the surface of the body, it has a depression like the surface of the first molaris. Into this depression of the incus the head of the malleus is received. The shorter of the two processes and the body of the bone lie on the margin of the circular opening of the tympanum; and the acute point of this process is turned back into the opening of the mastoid cells. The long leg or process of the incus hangs down free into the tympanum†, and has attached to its point the os orbiculare.

The OS ORBICULARE or lenticular bone is like a grain of sand in size, and is the smallest bone of the body: it is a medium of articulation betwixt the incus and stapes; and were it to be magnified, it would resemble the body of a vertebra.‡

The STAPES§ or stirrup is well named, for it has a very close resemblance to a stirrup-iron; the little head is articulated with the os orbiculare; the arch of the bone is exactly like that of the stirrup-iron, but elegantly grooved within, so as to give lightness to the bone. It has a membrane stretched across it. The base answering to that part of the stirrup-iron upon which the foot rests is not perforated, nor is it of a regular form, but is flat on one side, corresponding with the foramen ovale. It is this base of the bone which is attached to the membrane stretched over the foramen ovale.

CONNECTION AND MOTION OF THESE BONES.

The malleus, hanging on that part which we have called the neck of the bone, has the long handle or body of the bone stretched down upon the membrane of the tympanum. It is destined to receive the oscillations of that membrane.

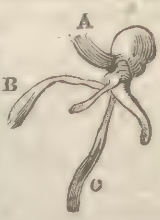
The head of the malleus is so articulated with the incus, that the degree of motion communicated to that bone is much increased.

From this scheme, we see, that the head of the malleus is so articulated with the body of the incus, that the centre of motion of the incus is in a line drawn through the centre of its body, and, consequently, that the extremity of the long process, to which we see the os orbiculare and stapes attached, moves through a greater space than that which receives the impulse of the head of the malleus. Thus, a very small degree of motion communicated by the head of the malleus to the body of the incus must be greatly increased in the extremity of the long process of the incus, and, consequently, this mechanism of the bones essentially assists in giving strength to the vibration which is transmitted inward to the seat of the nerve.

* See plate 2. fig. 1. A.
† See plate 2. fig. 1. B.
‡ Sœmmerring supposes he has disproved the existence of this bone. See plate 2. fig. 1. D.
§ See plate 2. fig. 1. C.

The os orbiculare stands simply as a link of communication betwixt the extremity of the incus and the upper part of the stapes, and its use is evidently to promote the accurate and perpendicular motion of this long lever of the incus upon the head of the stapes; for, if this bone had not been so placed, the motion of the long lever of the incus must have given an obliquity to the impulse upon the stapes. The base of the stapes almost completely fills up the foramen ovale. It is seated on a membrane which is stretched over the foramen.* The stapes, then, acts like a piston on a membrane of much less circumference than that of the membrana tympani. From all which considerations, we may learn how much the vibration produced by the agitation of the air in the outer canal of the ear is increased, before it strikes upon the fluids of the labyrinth.

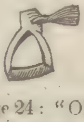
OF THE MUSCLES WITHIN THE TYMPANUM.†



A. Laxator tympani.

B. Externus mallei.

C. Tensor tympani.



Stapedius.

The laxator tympani arises from the upper part of the edge of the tympanum, near the part to which the membrane of the tympanum adheres, and is inserted into the handle of the malleus, near the root of its shorter process. The TENSOR TYMPANI‡ arises from the upper part of the Eustachian tube; it lies along the side of the tube, and is inserted into the handle of the malleus below the slender process. The external or superior§ muscle of the malleus, which is denied by some anatomists to be of the nature of muscle, comes from the fore and upper part of the

* Valsalva has the following observation, see page 24: "Olim namque in cujusdam surdi cadavere surditatis causam in eo sitam inveni nempe quod indicata membrana in substantiam osseam indurata, unum continuatum os constituebat cum basi stapedis et margine fenestræ ovalis."

† Musculus processus minimi mallei. Valsalva.

‡ Musculus processus majoris mallei.

§ Musculus processus minoris. Valsalva.

tympanum, and is fixed by a small tendon to the processus gracilis of the malleus.

The STAPEDIUS* is the smallest muscle, and is attached to the smallest bone. It has a small round fleshy belly, taking its origin from the pyramid, and is inserted by a small round tendon into the head of the stapes.

As all these muscles are inserted either into the malleus or stapes, and not into the middle bones, it would appear that their operation is chiefly upon the membranes of the tympanum, and of the foramen ovale, through the medium of the bones immediately attached to them.

Sir E. Home, in the Philosophical Transactions for 1800, asserts, that the membrana tympani is muscular; that its fibres run from the circumference towards the centre; and that they are attached to the malleus.

But what is the supposed use of this muscular membrane? Sir E. Home says, it is principally by means of this muscle that accurate perceptions of sound are communicated to the internal organ; that it is by means of this muscle that the membrana tympani is enabled to vary its degree of tension, so as to receive the vibrations in the quick succession in which they are conveyed to it. But we have seen, that the tension and relaxation of the membrana tympani is already sufficiently provided for: "the malleus has three muscles by which it is moved; one of them is called the tensor, from its pulling the malleus inward, and tightening the membrane of the tympanum; the other two act in an opposite direction, and relax the membrane."† We should naturally suppose this to be sufficient; but, according to Sir E. Home, these muscles act only to bring the membrane into such a degree of tension, as to enable the minuter changes of the muscular membrane to have their full effect; and that the play of these muscles gives the perception of grave and acute tones.

But the more favourite idea of Sir E. Home is, that, upon the accurate adjustment of the membrana tympani, the difference between a musical ear, and one which is too imperfect to distinguish the different notes in music, depends; that this jugdment or taste is owing to the greater or less degree of nicety with which the muscles of the malleus render the muscular membrane capable of being truly adjusted; if the tension be perfect, all the vibrations produced by the action of the radiated muscle will be equally correct, and the ear truly musical.

Sir E. Home proceeds upon the idea, that the membrane of the tympanum is like a musical instrument, or, as he expresses himself, like a monochord; but he is fundamentally wrong in supposing, that it requires a more delicate organ to be perceptible of musical tones than of articulate sounds or language. In the first place, we may require an explanation of the use of that muscle which is inserted into the stapes. This stapedius muscle would seem to have the same use, and to affect that bone in the same manner, in which the muscles of the malleus affect it. Surely Sir E. Home will not go so far as to say, that the mem-

* This muscle is particularly strong in the horse, where it was first discovered by Casserius.

† Sir E. Home's Lecture.

brana fenestræ ovalis is also muscular. It may be further worthy of attention, in considering this subject, that whatever affects the membrane of the tympanum, affects, also, the membrane of the vestibule.

In the paper already quoted, the following case is given, as illustrating the manner in which the loss of the natural action of the muscles affects the ear, in regard to its capacity for music. A gentleman, thirty-three years of age, who possessed a very correct ear, so as to be capable of singing in concert, though he had never learned music, was suddenly seized with a giddiness in the head, and a slight degree of numbness in the right side and arm. These feelings went off in a few hours, but on the third day returned; and for several weeks he had returns of the same sensations. It was soon discovered that he had lost his musical ear; he could neither sing a note in tune, nor in the smallest degree perceive harmony in the performance of others. For some time, he himself thought he had become a little deaf, but his medical attendant was not sensible of this in conversation. Upon going into the country, he derived great benefit from exercise and sea-bathing.

In this case, continues Sir E. Home, there appeared to be some affection of the brain, which had diminished the action of the tensor muscles of the membrana tympani, through the medium of the nerve which regulates their actions; this gradually went off, and they recovered their action.

Another case is given of a young lady who was seized with a frenzy which lasted several years, when, from being without a musical ear, she came to sing with tolerable correctness, to the astonishment of her friends.

We now proceed to put the incorrectness of this reasoning, concerning the muscular power of the membrane of the tympanum, in a more particular point of view, leaving to Sir E. Home's paper only the merit of ingenuity. Sir A. Cooper was led to pay particular attention to the action of the membrane of the tympanum, from being consulted in a case where the membrane was lost, with little injury to the function of the organ.* He found, that, instead of the total annihilation of the

* Case.—This gentleman had been attacked, at the age of ten years, with an inflammation and suppuration in his left ear, which continued discharging matter for several weeks: in the space of about twelve months after the first attack, symptoms of a similar kind took place in the right ear, from which matter issued for a considerable time. The discharge, in each instance, was thin, and extremely offensive to the smell; and in the matter, bones, or pieces of bones, were observable. The immediate consequence of these attacks was a total deafness, which continued for three months: the hearing then began to return; and, in about ten months from the last attack, was restored to the state in which it at present remains. Having filled his mouth with air, he closed the nostrils, and contracted the cheeks; the air thus compressed, was heard to rush through the meatus auditorius with a whistling noise, and the hair hanging from the temples became agitated by the current of air which issued from the ear. When a candle was applied, the flame was agitated in a similar manner.

Sir A. Cooper then passed a probe into each ear, and he thought the membrane on the left side was entirely destroyed, since the probe struck against the petrous portion of the temporal bone. The space usually occupied by the membrana tympani was found to be an aperture without one trace of membrane remaining. On the right side, also, a probe could be passed into the cavity of the tympanum; but here, by producing it along the sides of the meatus, some remains of the circumference of the membrane could be discovered, with a circular opening in the centre about the fourth of an inch in diameter. See Trans. Roy. Soc. for 1800. Part. I. p. 151.

powers of the organ, the gentleman was capable of hearing whatever was said in company, although the membrane of both ears was destroyed. He could even hear better in the ear in which no traces of the membrane remained. This gentleman was only in a small degree deaf from the loss of the membrane; but his ear remained nicely susceptible of musical tones, "for he played well on the flute, and had frequently borne a part in a concert; and he sung with much taste and perfectly in tune." This case puts aside, at once, that theory which supposes the musical ear to depend on the minute play of the muscles of the tympanum.

It appears, from these and other instances, that the membrane of the tympanum may be destroyed, that the bones may be washed out by matter formed in the tympanum, and still the patient retain the use of the organ. But this is only while the stapes retains its place; for if this bone be destroyed, the membrane of the foramen ovale will be destroyed, and the fluids of the labyrinth be allowed to flow out, or be otherwise lost. We see that, if the chain of bones, and only a part of the membrana tympani be left, still this shred of membrane, if it be not detached from the handle of the malleus, will vibrate in the air, and communicate those motions through the other bones to the vestibule. We see, also, that though the bones only remain, and though they be detached from the membrane of the tympanum, the sound will still be communicated. We see, that a rupture of the membrane will not destroy the organization so far as to prevent the hearing, unless there follow clots of blood or inflammation, suppuration, or fungus. When Sir A. Cooper found that the membrana tympani could be torn without injuring the organ, he did not stop short in his investigation: but as he found, by daily experience, that obstruction of the Eustachian tube caused deafness, he thought of puncturing the membrana tympani, as a cure for that kind of deafness. He expected, by this operation, to give elasticity to the confined air. Accordingly, by puncturing the membrane of the tympanum with a small trocar, he found, with much satisfaction, that the hearing was instantly restored.*

Valsalva made a good distinction, when he said, that the membrane of the tympanum was not absolutely necessary to hearing, but only to perfect hearing. We have, in this fact, the explanation of the following circumstance, amongst many others: "In naturali surditate a conformationis vitio inter tandem istud experimentum (viz. an ossiculi et membrana tympani aliquis sit usus auditum), quod inopinato et feliciter successit cuidam, qui intruso auri scalpio in aurem profundissime disrupit tympanum, fregitque ossicula et audivit."† Willis also knew, that the destruction of the membrana tympani did not deprive the person of hearing. *Vid. de Anima Brutorum.* A most ingenious paper is given to the Philosophical Transactions, by Dr. Wollaston, in which it is shown

* I am only afraid that such punctures will not continue open, as in Valsalva's experiments they healed up very soon. But, when there is no other ingress and escape to the air in the tympanum but through the punctured hole, it may tend to keep it open. See much of this in Morgagni, Epist. An. XII. The membrana tympani is very vascular. I have it red with injection. See Ruysch. fig. 9. tab. 9. Epist. An. VIII.

† Biolanus Enchirid. Anat. lib. 4. c. 4. See also Bonetus de Aurium Affect. Observ. IV.

that the exterior apparatus of the ear, and especially the parts in the cavity of the tympanum, are intended to give us the perception of acute and delicate sounds.

OF THE DISEASES OF THE TYMPANUM.

Valsalva denied the existence of periosteum to these bones of the tympanum, while he allowed that they had minute vessels distributed on their surfaces : but these vessels he supposed to creep along the naked bone independently of any membrane. This, however, is contrary to all analogy.* These bones, as well as the cavity of the tympanum, are covered with a very fine membrane or periosteum, which, after a minute injection, is seen covered with many small and distinct vessels, as well as with intermediate extravascular effusions of the injection, as happens in injecting in other membranes.

When the tympanum becomes diseased, there is fetid matter collected, the membrane of the tympanum suffers, and the small bones are sometimes discharged. In such a case we have little farther to do than, by injections, to prevent the matter from accumulating. But let us not confound this serious cause of deafness with the slighter suppurations in the outer passage of the tube ; although such suppurations in the tube of the ear are apt, when neglected, to destroy the membrane of the drum or tympanum, and to spread disease to these internal parts.

Authors make a display of the diseases of the membrane of the tympanum under the titles relaxatio, tensio nimia, induratio, and diruptio tympani † We have seen how little rupture of the membrane affects the hearing, and may thence conclude, that these fantastic opinions about tension and relaxation of the membrane deserve little notice. The idea of relaxation of the membrane of the tympanum, I have no doubt, has arisen from the effect of cold and moist weather in injuring the hearing ; but deafness from this cause is not produced by relaxation of the membrane of the tympanum, but by swelling of the mouth of the Eustachian tube.‡

Induration of the membrane is less of an imaginary disease, since there are instances of the membrane becoming thickened by inflammation, or cartilaginous, or osseous. The membrana tympani has been found to adhere to the extremity of the incus.§ Independently of the want of elasticity, which such an adhesion must produce, the vibration of the bones is prevented, and a degree of deafness is inevitable.

Fungous or polypous excrescences from the glands in the outer passage of the ear press back and destroy the membrane of the tympanum. In the cure of these by the knife, caustic, or ligature, there is much dan-

* See Ruysch. Epist. Anat. VIII. tab. 9.

† See Du Verney de Organo Auditus, p. 41.

‡ "Relaxatio fit ab humore superfluo qui membranam hanc humectat et symptoma hoc communiter cum obstructione meatus ex tumore glandularum conjunctum est, de qua jam supra dictum est : multum autem facit ad difficultatem audiendi in personis quæ defluxionibus catarrhosis obnoxiæ sunt et per eandem rationem austri nebulæ et aer pluvius auditum minuunt ut experiri quotidie possumus." *Du Verney*, loc. cit. p. 41.

§ See the London Philosophical Transactions for 1800, Part I. p. 5.

ger of injuring the membrane. Fungous tumours project from the membrane itself. A stroke upon the head will cause bleeding from the ear. This is often a sign of concussion of the brain; that is to say, a shock so severe as to rupture the membrane of the tympanum, will most probably injure the brain.* After bleeding from the ear, sometimes suppuration follows†; and blood flowing thus from the membrane of the tympanum, or other part of the ear, runs back into the cavity of the tympanum, and, filling it with coagulum, causes deafness, by obstructing the free motion of the bones and membrane. Sir A. Cooper, in a case of this kind, punctured the membrane, and, after a discharge of blood which continued for ten days, the hearing was gradually restored. It is supposed by that gentleman, that the blood effused becomes, in some instances, organized, so as to obliterate the tympanum, causing permanent deafness.

The danger in suppuration and caries of the tympanum is that the disease may penetrate backward into the mastoid cells and labyrinth, or into the brain itself; for inflammation and suppuration so confined amongst the deep recesses of the bone must give great torture, and be apt to extend the mischief to the brain; or the bone becoming carious, matter may be thrown out on the inside of the cranium, the effect of which must be mortal. Such I have seen to be the effect of suppuration deep in the ear. In a man who had been deaf for many years, and who was killed suddenly by a fracture of the skull, I found the cells of the temporal bones filled with matter, and a thin greenish fluid lay betwixt the temporal bone and dura mater. I have since found the caries of the petrous bone from this cause fatal in young people.

Valsalva gives us a case of injury of the head in which the patient was relieved while the discharge of pus by the ear was free; but he died when it was entirely suppressed.‡

But, after such suppuration as we should naturally think must totally destroy so delicate an organization, we are sometimes agreeably surprised with a gradual recovery of the function. This is owing to the nerve accomodating itself or becoming sensible to a less forcible impression, and by the ear acquiring new properties. I have already mentioned that the destruction of the mechanism of the tympanum arose sometimes from suppurations beginning in the outward ear; and we may suppose that the apparatus within the tympanum, when partially hurt, is sometimes capable of being, in some degree, replaced by a natural process; of which the following case from Valsalva is a remarkable proof:—

"I lately examined the ears of a woman whose hearing had been

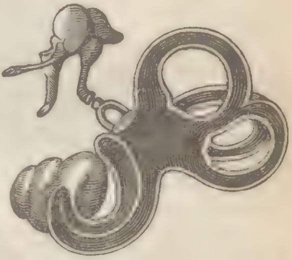
* When Valsalva found the ventricles of the brain full of blood, and blood also in the tympanum, he supposed that the blood in the latter was derived from the brain through certain foramina which he discovered. See p. 30.

† See Valsalva, p. 16.

‡ Valsalva, p. 83. See also a case in Bonetus de Aurium Affect. Observ. I. and Gul. Ballonius Epid. et Ephem. lib. 2. p. 270. When the matter was suppressed, there came pain of the head, and weight, which yielded to no remedy: on dissection, there was found an abscess within the skull. In Bonetus, loc. cit., a case is related, in which an ignorant surgeon compressed a fistulous ulcer in the ear, and so caused the death of the patient.

much injured by an ulcer of the tympanum and caries of the small bone. I found the ear in which she was deaf without a membrana tympani, and the stapes only remaining of the bones, and a fibrous mass, like an excrescence, in the tympanum. But, in the tympanum of the opposite ear, I found the membrana tympani almost entirely eroded; so that the malleus and incus were uncovered, and distinctly seen. I could even observe, that the long process of the incus, which should be articulated with the head of the stapes, was separated from it: but nature had curiously restored the eroded membrane. Thus, from the edge of the injured membrane, a new membrana tympani was obliquely stretched across the cavity of the tympanum, so as to exclude the malleus and incus from that cavity, but including the head of the stapes, as if nature, finding the separated bones no longer necessary, had attached the membrane to the head of the stapes."* We have already remarked, that, when the organ of one side is injured, we hear so much better with the other, that we attend only to the sensation conveyed by it, and neglect the duller sensation. The consequence of this is, that the bad ear becomes worse. It is much like that effect which takes place in eyes by squinting.

OF THE LABYRINTH.



DESCRIPTION OF THE FIGURE.

The labyrinth first cut out of the solid bone, and then opened so as to show the cavities. The central one, the vestibule; the semicircular canals; and the cochlea, so laid open as to exhibit part of the scala vestibuli and scala tympani. The chain of bones is attached, the stapes resting on the foramen ovale.

The labyrinth is the internal ear; the proper seat of the sense of hearing. It consists of the vestibule or middle cavity of the semicircular canals; and of the cochlea. It has its name from those cavities and tubes leading into each other in so intricate a manner, as to be followed out with much difficulty.

We understand that the cavities hitherto described in the human ear contain air, and communicate with the atmosphere: but, in the cavities we have now to describe, the nerve is expanded, and there is, in contact with it, not air, but an aqueous fluid. In treating of this division of our subject, we have, first, to attend to the forms of the cavities, as seen when sections are made in the dry bones next to the soft parts contained in those cavities; and, finally, to the distribution of the nerves. To give an idea of the exquisitely delicate and complex structure of the many canals, excavations, openings, sulci, and foveæ, of the bones; of the tubuli, sacculi, and partitions of the membranes; and, lastly, of the soft

* See Valsalva de Aure Humana, Tract. p. 79. In those deaf from birth it has been twice found that the *incus* was wanting. See Bonetus de Aur. Affect. Observ. IV.

expansions of the nerves, without the assistance of plates, would be impossible. Albinus, in his academical annotations, begins very formally a chapter on the ear; but, after a few words, dismisses the subject, referring merely to his plates.

The VESTIBULE, or central cavity of the labyrinth, is of an oval form, and about a line and a half in diameter.* It has two remarkable pits or hollows in it, and has numerous foramina opening from it into the neighbouring cavities, besides lesser foramina for transmitting that portion of the nerve which is distributed on the sacs contained in it. One depression or fovea is in the back or lower part of the vestibule, another in the outer and superior part of it: the one is circular, the other semi-oval. Morgagni, and other anatomists, examining the dry bones, speculated on their use in reverberating the sound in the cavity; but we must not regard them in this unnatural state. on the contrary, they contain in the living subjects membranous sacculi filled with fluid, in which membranes the nerve is finally distributed. That foramen over which the stapes is placed, and which is called the foramen ovale, transmits the vibration into the vestibule. For the foramen ovale opens directly into the vestibule, and through the vestibule, only, does the vibration of the bones in the tympanum reach the other parts of the labyrinth.

SEMICIRCULAR CANALS.—When we have cut into the vestibule, by taking away that portion of the os petrosum which is behind the meatus auditorius internus, we see five circular foramina: these are the openings of the semicircular canals. There are three semicircular canals; and they are distinguished by the terms, the superior or vertical, the posterior or oblique, and the exterior or horizontal. The one which, in this view, is nearest, is the opening common to the inner ends of the posterior and superior semicircular canals. When we pass a bristle into this common foramen, and direct it upward, it passes along the superior semicircular canal, and will be seen to descend from the upper part or roof of the vestibule, almost perpendicularly on the foramen ovale, which is open, and immediately opposite. If, again, we pass a bristle into the foramen which is near the bottom of the cavity, (and which will be just upon the edge of the fracture that has laid open the vestibule, if not included in it,) it will come out by the opening common to the superior and posterior semicircular canal. It has passed, then, along the posterior canal. The two openings of the exterior or horizontal canal are upon the back part of the vestibule; and the canal itself takes a circle which brings its convexity to the confines of the mastoid cells. These canals are formed of a very hard brittle bone; their calibre is so small as not to admit the head of a common pin; they form somewhat more than a half circle; and of each of them, one of the extremities is enlarged like the ampullula of fishes. Valsalva imagined that the enlarged extremities of these tubes were trumpet-like, to concentrate and strengthen weak sounds. We shall find, on the contrary, that there is in the human ear, as in fishes, a particular expansion of the nerve in these extremities of the tube, opposed to the circulatory vibration of the fluids in the canals.

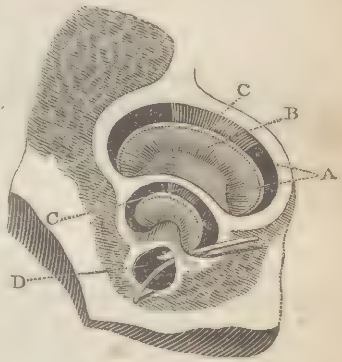
The COCHLEA.—The third division of the labyrinth is the cochlea

* Du Verney Œuvres Anatomiques.

It is so named from its resemblance to the shell of a snail, or from the manner in which its spiral lamina turns round a centre like a hanging stair. It has been minutely, but not simply, described; and, indeed, there can be nothing more difficult than to describe it in words.

When the os petrosum is cut from around the cochlea, it is seen to be of a pyramidal shape, and to consist of a scroll, making large circles at the base, and gradually lesser ones towards the apex. It is formed in the most anterior part of the petrous bone, and has its apex turned a little downward and outward; and the base is opposed to the great cul de sac of the internal meatus auditorius.

The spiral tube, of which the cochlea is composed, forms two turns and a half from the basis to the point; and it consists of the same hard and brittle matter with the semicircular canals. When the whole cochlea is cut perpendicularly in the dry state of the bones, and when the membranes have shrunk away or spoiled, the sides of the spiral canal appear like partitions, and are, indeed, generally described as such. In consequence of the spiral tube of the cochlea having its sides cut perpendicularly as in this figure, the cochlea appears as if divided into three circular compartments or successive stages; but there is really no such division; because the spiral turnings of the tube lead from the one into the other.



What gives particular intricacy to the structure of this part of the labyrinth is the LAMINA SPIRALIS.* This spiral partition runs in the spiral tube of the cochlea, so as to divide it in its whole length; and, in the fresh state of the parts, this lamina of bone is eked out by membrane, so as to form two perfectly distinct tubes. These tubes are the SCALÆ COCHLEÆ; they run into each other, or communicate at the apex of the cochlea; but at the base, the one turns into the vestibule, and the other opens into the tympanum by the FORAMEN ROTUNDUM.

In the middle of the cochlea there runs down a pillar, which is the centre of the circumvolutions of the scalæ. It is called the MODIOLUS. This pillar is of a spongy structure; and through it the nerves are transmitted to the lamina spiralis.

The modiolus opens towards the apex of the cochlea like a funnel; and when we take away the outward shell of the apex of the cochlea, which is called the CUPOLA, we look into this expansion of the upper part of the modiolus as into a funnel; it is therefore called the INFUNDIBULUM. The infundibulum is that part which, in a perpendicular section, we should call the upper partition D.†

* A, Lamina spiralis. B, Scala vestibuli. C C, Scala tympani. D, The hook of the lamina spiralis in the infundibulum.

† That is, supposing the cochlea to rest on its base, which it does not.

The scalæ, or divisions of the spiral tube of the cochlea, have a communication at their smaller extremities in the infundibulum; and as, again, their larger extremities do not open into the same cavity, but one into the vestibule, and the other into the tympanum, the vibrating motion, which is communicated through the cochlea, must pass either from the tympanum into the foramen rotundum, circulate round the modiolus by the scala tympani, pass into the lesser extremity of the scala vestibuli in the infundibulum, and circulate through it towards the base of the cochlea, until it pass into the vestibule; or it must pass from the scala vestibuli into the scala tympani. The first is the opinion of Scarpa and others. But I trust it will afterwards appear, that the oscillations of sound are in the first place conveyed into the vestibule, and thence circulate round both the semicircular canals and cochlea.

In the dry bones, when we cut into the cochlea, there appears a spiral tube, as I have described, with a partition running along it, and, of course, taking the same spiral turns with it towards the apex. This is the bony part of the lamina spiralis; but, as the membrane which extends from its circular edge quite across the spiral tube of the cochlea has shrunk and fallen away in the dry state of the parts, the lamina spiralis is like a hanging stair, and the scalæ are not divided into distinct passages. In this bare state of the shell of the cochlea, when we cut away the cupola or apex of the cochlea, and look down upon the infundibulum, we see the extreme point of the lamina spiralis rising in an acute hook-like point.

The modiolus or central pillar, and the lamina spiralis which encircles it, are of the most exquisite and delicate structure; for through them the portion of the seventh nerve destined to the cochlea is conveyed. To say that the modiolus is formed of two central bones, is saying that there is no central column at all; or that the modiolus is the cavity seen in the bottom of the meatus auditorius; and to affirm, at the same time, that the modiolus is a nucleus, axis, or central pillar, is a contradiction in terms.

When we break away the shell of the cochlea, and break off also the spiral lamina, we find the little funnel-like depression in the bottom of the meatus internus, reaching but a little way up into the centre of the cochlea. — We find this depression of the meatus auditorius internus perforated with innumerable small holes; and these foramina are so placed as to trace a spiral line, because they give passage to the nerves going to the spiral lamina, and must take the form of the diminishing gyrations of the lamina spiralis. In the centre of these lesser foramina, which are seen in the bottom of the great foramen auditorium internum, there is a hole of comparatively large size, which passes up through the middle of the pillar. The modiolus is formed of a loose spongy texture, and resembles the turns of a cork-screw; and this spiral direction is a necessary consequence of the lamina spiralis, being a continuation of the spongy or cribriform texture of the modiolus.

Internal periosteum of the labyrinth. — We find that the vestibule, the semicircular canals, and cochlea, besides their soft contents, which we have yet to describe, have their proper periosteum, which, after a minute injection, appears vascular; and this, as it has appeared to me, is particularly the case with the last-mentioned division of the laby-

rinth. I see very considerable vessels distributed on the vestibule; particularly, I see their minute ramifications on the circular fovea, while very considerable branches are seen to course along the semicircular canals. In the cochlea, I see distinct branches of vessels rising from the root of the lamina spiralis, and arching on the scalæ, to the number of ten in the circle; and, after a more minute injection, I have found the osseous part of the lamina spiralis tinged red, and the membraneous part of a deep scarlet.*

We have observed the MEATUS AUDITORIUS INTERNUS to be a large oval foramen in the posterior surface of the pars petrosa of the temporal bone. This tube transmits the seventh or auditory nerve. It is about five lines in diameter, but increases as it passes inward; and appears to terminate in two deep foveæ, which are divided by an acute spine. But the auditory foramen only appears to terminate in these foveæ, for they are each perforated by lesser holes, which lead into the three divisions of the labyrinth, whilst a larger one conveys a portion of the nerve through the cavities of the temporal bone altogether, and out upon the side of the face. This larger foramen is in the upper part of the superior and lesser fovea. It first ascends to near the surface of the petrous part of the temporal bone†, and then descends and turns backward, and takes a course round the tympanum above the foramen ovale, and close by the posterior semicircular canal. Its termination is the foramen stylo-mastoideum.‡ Where this canal of the portio dura advances towards the surface of the pars petrosa, it is joined by a very small canal which extends from the videan hole on the fore part of the inclining face of the bone: again, after it has passed the tympanum, it is joined by a short canal which receives the corda tympani, after it has passed the tympanum.

The other foramen which is in the upper and lesser fovea of the meatus internus is rather a cribriform plate, as it is a deep pit with many foramina in it. These lead into the vestibule, and form the MACULA CRIBROSA VESTIBULI.§ In the inferior and larger fovea, we observe several dark spots, which, when more narrowly examined, are also distinguished to be cribriform plates, or collections of lesser foramina. We particularly observe that conical cavity which is perforated with many little pores for transmitting the nerve into the cochlea, and which we have already mentioned. From the form which these foramina take, this is named the TRACTUS SPIRALIS FORAMINOLOSUS. These foramina, after passing along the modiolus cochleæ, turn at right angles, and pass betwixt the plates of the lamina spiralis.

Besides the tractus spiralis foraminolosus the bottom of the larger fovea has many irregular foramina, which are like cancelli: for very delicate spiculæ of bone stand across some of them. There is a range of these foramina which stretches from the tractus spiralis. This may properly be called the TRACTUS CALTHRATUS RECTUS;‖ they do not

* In a preparation before me, I see a considerable artery derived from the basilar artery, entering the meatus auditorius internus. From this trunk, I conceive that most of these arteries which I have described are derived.

† In the fœtus, it becomes here superficial.

‡ This is the aqueduct of Fallopius.

§ See Scarpa, Plate VII. fig. i. m.

‖ Tractus spiralis foraminolosi initium. *Scarpa.*

lead into the vestibule, but into the beginning of the lamina spiralis, where it divides the two scalæ cochleæ, and turns the orifice of one of them (by a beautiful curve) out into the tympanum.

Nearer to the ridge which divides the two foveæ of the meatus internus, there is a little pit which has also a cribriform plate (like that which is in the upper fovea, and is called macula cribrosa); opposite to this point the inside of the vestibule is rough and spongy: it transmits a portion of the nerve to the sacculus in the hemispherical sinus of the vestibule.*

OF THE SOFT PARTS CONTAINED IN THE LABYRINTH.

Within the vestibule, semicircular canals, and cochlea, there are soft membranes independent of the periosteum. These form sacculi and tubes which contain a fluid, and have the extreme branches of the portio mollis distributed among them. Betwixt the soft and organised sacculi and tubes and the periosteum of the osseous labyrinth a watery fluid is exuded.

Sacculus vestibuli.—The hemispherical and semi-elliptical foveæ which we have described in the vestibule contain, or at least receive partially, to sacculi. The sacculus which is in the hemispherical cavity receives the most convex part of the sacculus vestibuli. This sac is distended with a fluid, and is pellucid, and fills the greater part of the vestibule; for only a part of it is received into the fovea. It forms a complete sac, and has no communication with the other soft parts of the labyrinth, though lying in contact with the alveus communis, presently to be mentioned; and being surrounded with an aqueous fluid, it must receive the impressions of sound in common with them.

Alveus communis ductuum semicircularum.—This sacculus lies in the semi-elliptical fovea of the vestibule, or like the other sacculis, is in part received into it. This sacculus receives the extremities of the tubuli membranacei which lie in the semicircular canals; it is a little bag common to them, and connecting them altogether, as in fishes; it is filled with fluid, and is so pellucid, as to be distinguished with much difficulty. Upon pressing the common sac, or the ampullulæ of the semicircular canals, the fluids are seen to circulate along the membranous tubes of the canals. These two sacculi in the vestibule lie together, and firmly adhere, but do not communicate; yet (as may be easily imagined) they cannot be separated without tearing the partition.

Tubuli membranacei.—The tubuli membranacei are the semicircular tubes which pass along the osseous semicircular canals, and to which the latter are subservient, merely as supporting them. They are connected by means of the common alveus in the vestibule, and form a distinct division of the organ.

It was believed by anatomists formerly, that the osseous canals had the pulp of the nerve expanded on their periosteum. But we find, on the contrary, that the membranous tubuli do not touch the bones, but are connected with them by transparent cellular membrane-like mucus. Each of the semicircular membranous tubes has one extremity swelled out into an ampulla of an oval form, answering to the dilated extremity

* Scarpa.

of those osseous tubes which we have already described. These ampullæ have the same structure and use with those formerly mentioned in describing the ear in fishes. When the central belly of these tubes is punctured, both the ampullæ and the membranous canals fall flaccid.

Besides those vessels which we have described running along the periosteum of the cavities of the labyrinth, vessels also play upon the sacculi and membranous tubes. The ampullæ of the tubes are, in a particular manner, supplied with blood-vessels.*

In the COCHLEA there is also a pulpy membrane, independent of the periosteum; but of this I can say nothing from my own dissection.

OF THE NERVE.

As the seventh pair of nerves arise in several fasciculi, they form what would be a flat nerve, were it not twisted into a cylindrical form adapted to the foramen auditorium internum. While these fasciculi are wrapped in one common coat, they are matted together. In the canal, the nerve is divided nearly into two equal parts†; to the cochlea and to the vestibulum and semicircular canals. Those fasciculi, which are destined for the vestibule, are the most conspicuous; and on the portion destined for the ampullæ of the superior and external canal there is formed a kind of knot or ganglion.

Before the auditory nerves pass through the minute foramina in the bottom of the meatus auditorius, they lay aside their coats, and become more tender and of a purer white colour; and by being still further subdivided by the minute branching and divisions of the foramina, they cannot be followed, but finally expand in a white pulpy-like substance on the sacs and ampullæ. We must, however, recollect that there was a difference to be observed in the apparent texture of these expanded nerves in the lower animals: we may observe here, also, that part of the nerve which is expanded on the common belly or sacculus tubulorum, is spread like a fan upon the outer surface of the sac, and has a beautiful fibrous texture; but upon the inside of the sac upon which it is finally distributed it loses the fibrous appearance. We must suppose its final distribution to be in filaments so extremely minute that we may call it a pulp; though by the term it must not be understood that an unorganised matter is meant.

That part of the nerve which stretches to the ampullæ immediately divides into an opaque white mucous-like expansion. Beyond these ampullæ there has been no expansion of the nerve discovered in the membranous tubes.

The sacculus vestibuli‡ is supplied by a portion of the nerve which perforates the macula foraminolosa, in the centre of the osseous excavation, or that which receives into it part of the sac. This part of the nerve is expanded in a soft mucous-like white matter in the bottom and sides of the sac.

* "Cæterum universum hoc canaliculorum membraneorum alveique communis machinamentum, sanguiferis vasis instruitur, quorum crassiora, circum alveum communem, serpentino incessu ludunt: crebra et conferta alia *ampullæ* imprimis recipiunt ob quam causam rubellæ plerumque sunt et cruore veluti suffusæ." *Scarpa*, p. 47.

† Of the portio dura we have already spoken.

‡ *i. e.* In opposition to the sacculus tubulorum.

A division of the nerve, as we have already explained, passes from the meatus auditorius internus through the cribriform base of the modiolus into the cochlea. Owing to the circular or spiral form of the foramina when the nerve is drawn out from the meatus, its extremity appears as if it had taken the impression of these foramina from the extremities of the torn nerves preserving the same circular form. These nerves, passing along the modiolus and scalæ cochleæ, are in their course subdivided to great minuteness. Part of them perforate the sides of the modiolus, whilst others pass along betwixt the two plates of the lamina spiralis, and out by the minute holes in the plates and from betwixt their edges. Lastly, a central filament passes up through the centre of the modiolus, and rises through a cribriform part into the infundibulum to supply the infundibulum and cupola.

Where the nerves pass along the lamina spiralis, their delicate fibres are matted together into a net-work. According to the observation of Dr. Monro, they are quite transparent on their extremities.

OF HEARING.

When aërial undulations were, by the experiments on the air-pump, first proved to be the cause of sounds, philosophers looked no further to the structure of the ear than to discover an apparatus adapted for the reception of such vibrations. When they observed the structure of the membrane of the tympanum, and its admirable capacity for receiving these motions of the atmosphere, they were satisfied, without considering the immediate objects of sensation. In the same way, an ignorant person, at this day, would rest satisfied with the fact that sound was received upon the drum of the ear. But after so minutely explaining the anatomy of the ear, it becomes us to take a general survey of a structure the most beautiful which the mind can contemplate. We cannot say that it surpasses in beauty the structure of other parts of the body: but the parts are adapted to each other, in a manner so simple, efficient, and perfect, that we can better understand and appreciate the harmony of their structure than that of organs which perform their functions by qualities and actions almost entirely unintelligible to us.

We see that the external ear collects the vibrations of sound as it moves through the atmosphere in circular undulations proceeding from the sonorous body: we may observe, that where the necessities of animals require them to be better provided with this external part of the organ than man, the superiority is in the increased sensibility to sounds, and in judging of their direction. Notwithstanding it is obvious that the horse and ass, for example, use their ears to judge of the direction of sound, experiments of cutting off these appendages, we are told, have not hurt the power of the organ; and man, from the perfection of the internal organ, excels all animals in the capacity of the ear for articulate and musical sounds.

From the external ear we observe, that the trumpet-like tube conveys the sound inward to the membrane of the tympanum. Behind the membrane of the tympanum, there is a cavity which, in order to allow of the

free vibration of the membrane, contains air. When this air is pent up, by the swelling or adhesion of the Eustachian tube, the elasticity of the air is diminished, and the membrane prevented from vibrating.*

In the tympanum, we have seen that the operation of the chain of bones is to increase the vibration received upon the membrane of the tympanum, and to transmit it to the membrane of the foramen ovale. In the cavity of the tympanum we observed two foramina, the foramen ovale and the foramen rotundum, both of which lead into the labyrinth; but one of them (the foramen ovale) into the vestibule, the other (the foramen rotundum) into a scala of the cochlea: now it becomes a question, whether the oscillations of sound pass by one or by both of these foramina?

It is contended, that the sound passes in both ways, that is, along the solid bones, and through the air of the tympanum. Did it pass through the air, why is there all this expense of apparatus?—why a membrane of the tympanum; for unless the impressions of sound were to be conveyed as powerfully through the air as by the bones, why are they there at all? If the air were the medium, then the chamber containing it should be direct and regular. Again, it is with the same inconsistency maintained that the tympanum is more capacious in the elephant, and in nocturnal birds, so as to increase the acuteness of hearing. The obvious objection to this is, that the walls of the cavity are irregular in a singular degree, with minute cells, spines, and processes, presenting no where a regular concave for reverberation. If a person should show me an irregular piece of rock crystal, opaque white, from the variety of its reflecting surfaces, and say it was a lens, I would as soon believe it was a magnifying glass, as that the cells of the cavity of the tympanum were for reverberating and directing the sounds.

An absolute confusion of ideas has led to the opinion, that the foramen rotundum receives the undulation of the air. It is not enough to state to those *physiologists*, that the foramen ovale is directly opposite the membrane of the tympanum, and the foramen rotundum turned away from it. No, they say, that is the very reason, because it does not receive the impulse directly, but by reverberation, and obliquely. If there were any hope of arguing against these opinions, we might state the matter thus:—if the sounds arrived from different sources, and came in various directions, they might (if the surfaces were regularly adapted) be reverberated to some common centre, and thereby strengthened (of which we have an example in the outward ear); but the sound comes only by the motion of the membrane of the tympanum, through the tube of the ear: it is already concentrated; and if it were now to be directed against the walls of these passages, it might be dissipated, but how is it to be concentrated again?—and if concentrated, in what degree can it be stronger than when it entered the tympanum?

In the labyrinth there is no air, but only an aqueous fluid: now this, we have seen, conveys a stronger impulse than the atmosphere; stronger in proportion to its greater specific gravity and want of elasticity; for an elastic fluid like air may be compressed by concussion, but an inelastic

* See *Recherches, &c. relatives à l'organe de l'ouie et à la propagation des sons*, par M. Perolle, Sociét. R. de Médecine, tom. iii.

fluid must transmit fairly every degree of motion it receives. But if the fluid of the labyrinth be surrounded on all sides; if, as is really the case, there can be no free space in the labyrinth, it can partake of no motion, and is ill suited to receive the oscillations of sound. Against this perfect inertia of the fluids of the labyrinth I conceive the FORAMEN ROTUNDUM to be a provision. It has a membrane spread over it, similar to that which closes the foramen ovale. As the foramen ovale receives the vibrations from the bones of the tympanum, they circulate through the intricate windings of the labyrinth, and are again transmitted to the air in the tympanum by the foramen rotundum. Without such an opening there could be no circulation of the vibration in the labyrinth; no motion of the fluids communicated through the contiguous sacculi, nor through the scalæ of the cochlea; because there would be an absolute and uniform resistance to the motion of the fluids. But as it is, the provision is beautiful. The membrane of the foramen rotundum alone gives way of all the surfaces within the labyrinth, and this leads the course of the undulations of the fluid in the labyrinth in a certain unchangeable direction.

To me it appears, that to give a double direction to the motion of the fluids, or to the vibration in the labyrinth, far from increasing the effect, would tend to annihilate the vibrations of both foramina by antagonising them. The common idea is, that there is a motion communicated through the membrane of the foramen rotundum along the scala tympani, and another through the foramen ovale into the vestibule, and through the vestibule into the scala vestibuli; and that the concussion of these meet in the infundibulum of the cochlea. But as there is no space for motion in the fluids, in either the one or other of these tracts, the vibration must have been received in the infundibulum at the same time that the motion was communicated to the membranes of the foramen ovale and rotundum; for if a tube full of water, a mile in length, loses one drop from the extremity, there must be an instantaneous motion through the whole to supply its place. The evident consequence of this double impulse would be (if they were of the same strength) to suppress all motion in the fluids of the labyrinth.

But we have shown that the strength of the vibration communicated to the foramen ovale and foramen rotundum are not the same: for the mechanism of the bones in the tympanum is such as to accumulate a greater force or extent of motion on the membrana ovalis than is received upon the membrana tympani; therefore the lesser vibration, which is communicated through the medium of the air in the tympanum, cannot be supposed capable of opposing the stronger vibration which is conveyed from the foramen ovale through the labyrinth. Besides, the air in the tympanum has a free egress, and cannot therefore strike the membrane on the foramen rotundum forcibly.

For these several reasons, I conceive that the following account of the manner in which the sound is conveyed is erroneous:—" Et quo ad zonam cochleæ spiralem quoniam altera cochleæ scala in vestibulo patet, altera a FENESTRA ROTUNDA initium sumit, atque earum utraque aqua labyrinthi repleta est, et scalæ in apice cochleæ simul communicant, zona spiralis inter duas veluti undas sonoras media, a tremoribus per vasim stapedis, simulque ab iis per membranam *fenestræ rotundæ* advectis utra-

que in facie percellitur et una cum pencillis acoustici nervi per eam distributis contremiscit: quibus porro omnibus, in ampullis videlicet canaliculorum semicircularium alveo eorum communi, sacculo vestibuli spherico et lamina cochleæ spirali acoustici nervi affectionibus auditum contineri nemo non intelligit."*

As to the immediate seat of the sense of hearing, there cannot, after what has been explained regarding the distribution of the nerves, remain any controversy; though before the structure of the ear was so well understood, some imagined that the vestibule, others that the middle part of the semicircular canals, was the seat of hearing; others, again, that the lamina spiralis was better adapted for receiving the vibrations of sound. It is evident that the soft expansion of the nerve, in all the three divisions of the labyrinth, is destined to receive the undulation of the contained fluids, and that this motion of the fluids gives to the nerve, or to the nerve and brain conjointly, the sensation of hearing.

Since we have, in some measure, traced the structure of the ear from the animals of a simple structure to those of a more complicated organisation, and have observed some parts of the ear common to all animals, some peculiar to certain orders; and since all have the sense of hearing, more or less acute, it becomes natural to enquire what are the parts of the organ the most essential to the mere perception of sound, and what parts conduce to a more perfect state of the sense.

All the external apparatus of the ear is not necessary to give the animal the simple perception of sound. There are many classes of animals altogether without them, and even in man we see that they are not absolutely necessary; since, when deprived of them by disease, he still enjoys the sense. He is deprived of no essential variety of the sensation: he is capable of perceiving the distinctions of articulate sound; and still possesses his musical ear. The external apparatus of the ear, the membrane of the tympanum, and the little bones, receive, concentrate, and increase the tremors of the external air, and render the lesser motions or more acute impressions audible. They are not essential to hearing. These are the parts calculated only to receive the minute undulations of the air, and to perfect our sense of acute sounds.

It would appear, that the simple sac of the vestibule is sufficient to receive the impression in some animals, and that in many the vestibule and semicircular canals form all the organ of hearing. It is evident, therefore, that these are the most essential parts.

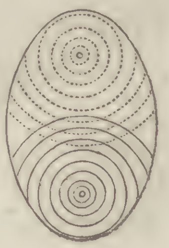
We find, however, that the cochlea exists, though it be imperfect, in birds; that it is fully formed only in man, and in quadrupeds: from which we may conclude, that it is subservient to the more exquisite sensations. We are not, perhaps, warranted in concluding that any one part of the organ of hearing bestows the pleasures of melody and harmony, since the musical ear, though so termed, is rather a faculty depending on the mind. Yet, when we see that the sacculi of the vestibule is common to all creatures; and the semicircular canals common to fishes, birds, and beasts; and when, in the lamina spiralis of the cochlea, we see a more perfect preparation for variety of impression; and which by comparative anatomy is marked as the perfection of the

* Scarpa, p. 61.

organ of hearing, we are naturally drawn to observe this part more narrowly.

Even after studying, with all diligence, the anatomical structure of the ear, we cannot but be astonished with the varieties to be found in the sensation; for example:—"The ear is capable of perceiving four or five hundred variations of tone in sound, and probably as many different degrees of strength; by combining these, we have above twenty thousand simple sounds that differ either in tone or strength, supposing every tone to be perfect. But it is to be observed, that to make a perfect tone, a great many undulations of elastic air are required, which must all be of equal duration and extent, and follow one another with perfect regularity; and each undulation must be made of the advance and recoil of innumerable particles of elastic air, whose motions are all uniform in direction, force, and time. Hence we may easily conceive a prodigious variety in the same tone, arising from irregularities of it occasioned by constitution, figure, situation, or manner of striking the sonorous body; from the constitution of the elastic medium, or its being disturbed by other motions; and from the constitution of the ear itself upon which the impression is made. A flute, a violin, a hautboy, a French horn, may all sound the same tone, and be easily distinguishable. Nay, if twenty human voices sound the same note, and with equal strength, there will still be some difference. The same voice, while it retains its proper distinctions, may yet be varied many ways: by sickness or health, youth or age, leanness or fatness, good or bad humour. The same words, spoken by foreigners and natives, nay, by different provinces of the same nation, may be distinguished."*

There are several interesting subjects which have not met with sufficient attention. On what does this variety in the sensation depend? Does the vibration strike on different parts, and re-echo along different passages of the labyrinth, so as to move particular divisions of the auditory nerve? Or does the whole fluid of the labyrinth move in every sound, and is every filament of nerve struck? I must suppose that the first opinion is true. It appears necessary, to account for that extraordinary compass and variety in the sensations of this organ. And if the varieties in the impression had resulted from a pulse agitating indiscriminately the whole nerve, it would seem that the object would have been better accomplished by the uniform expansion of the medulla of the nerve over all the surfaces and cavities, as in the eye. But as, on the contrary, the medullary matter lies in patches, it is probable that those are the centres where undulations of sound meet, reflected from the surrounding vaults.



In an elliptical chamber, a person standing in one of the foci is heard in a whisper by a person standing in the other focus: for by the regular elliptical form, the waves or pulses are reflected to the foci. The vestibule has regular concavities, which we can imagine to produce such a concentration of sound. The cavity of the tympanum, on the contrary, having no such regularity of form (as I have argued above,) can produce no such concentration of the pulses of sound.

* Reid's Enquiry, p. 98.

Another difficulty presents in accounting for the direction of sound. Authors have left us quite in the dark on this subject. That two ears, by receiving the impressions unequally as we turn the head, affords a means of judging of the directions of sounds, is obvious ; but we possess the same power through the operation of one ear. Some have been so hardy as to explain this on the supposition that the impressions are received on the head, and that we judge in this manner of the direction of them ; which were, I think, to make the ear a superfluous ornament. Are the sounds reflected from the different surfaces of the outer ear, so as differently to affect the membrane of the tympanum and the adjoining muscles ? it is not easy to prove this. Does ventriloquism throw any light on this subject ? If we know how we are deceived in the direction of sounds, we may learn by what means we judge of them. This would make the modifications of the intensity of impression the means by which we judge of the direction of sound. It may countenance such an explanation if we consider the nicety with which we judge of the distance of a sonorous body ; we judge, at least, as accurately of distance by the ear as by the eye.

I must again repeat that the cochlea is the more important part of the organ, or rather the refined and higher part of the apparatus ; for the vestibule is universal, and the semicircular canals common to fishes, birds, and quadrupeds. We think that we find in the lamina spiralis the only part adapted to the curious and admirable powers of the human ear, for the enjoyment of melody and harmony. It is in vain to say, that these capacities are in the mind and not in the outward organ. It is true, the capacity for enjoyment, or genius for music, is in the mind. All we contend for is, that those curious varieties of sound which constitute the source of this enjoyment, are communicated through the ear, and that the ear has *mechanical* provisions for every change of sensation.

There is no part of the proper organ which appears susceptible of the variety of musical notes but the scala of the cochlea. Its breadth is in regular gradation of parts from the base towards the point or apex ; and whether the fibres were to be taken as the cords of a harp, or the tubes like the ora of a wind instrument, every gradation of sound may be supposed to have here its corresponding organ to vibrate, and by its vibration to move a distinct part of the auditory nerve.

Let us, then, turn to the consideration of the effects of these musical tones upon the mind.

There is nothing more curious than the relations established betwixt the senses and the ruder bodily operations. We have seen how the motions of the body and limbs added to the perfection of the eye, an organ which we should suppose neither required nor admitted addition of powers from so unexpected a source. The motions of the limbs are in constant relation to the enjoyment received through the ear, from the tatooing with the fingers on the table to the richest combination of sounds from a whole orchestra ; for, in all this compass of enjoyment, rhythm is a necessary part.

Rhythm is a regular and agreeable return of an expected note with which the body readily accords. We cannot walk, nor jump, nor dance, nor strike with a hammer, without feeling a desire that the stroke should be in a certain regulated succession. This is rhythm, and is a necessa-

ry part of music. Melody is something more; it is a succession of notes which bear a relation in the time of their vibrations; the sound still dwelling on the memory is succeeded by sounds which, from the proportions of their vibrations, are agreeable and melodious. Harmony is the concurrence of sounds which correspond in certain of their vibrations. Music has another power over us by a resemblance to the expression of human suffering and passion, by which a melody is continually suggesting circumstances of interest, while by association it unlocks the memory, and keeps the mind revolving in agreeable reverie.

OF THE DISEASES OF THE INTERNAL EAR.

Of all the causes of deafness, that which proceeds from an organic disease of the brain is, of course, the most dangerous. In apoplectic affections, with faltering of speech and blindness, deafness is also produced by the general affection of the brain. But worst of all is the case where a tumour of the brain, or betwixt the cerebrum and cerebellum, compresses the origin of the nerves.* I have, however, observed, that a tumour in the *vicinity* of the origin of the auditory nerve, though it ran its course so as to prove fatal, had rather a contrary effect on the organ of hearing; and while the pupil of the eye remained stationary, and the man saw indistinctly, he had a morbid acuteness of hearing. This had probably been produced by the surrounding inflammation having extended to the origins of the auditory nerves. The auditory nerve often becomes morbidly sensible, and the patient suffers by the acuteness of perception, or is distressed with the tinnitus aurium, which is, in this case, analogous to the flashes of light which sometimes affect the eye in total darkness, and which those experience who are totally blind, or have cataract. So morbidly acute does the sensation sometimes become, that the slightest motion of the head will excite a sensation like the ringing of a great bell close to the ear.† With delirium, vertigo, epilepsy, hysteria, the increased sensibility of the organ becomes a source of painful sensation.

The ear is sometimes affected by sympathy of parts: for example, from foulness of the stomach and bowels, as it is termed; and the same reason may be assigned for the complaint of hypochondriacs, that they are molested with strange sounds. In the case of intestinal worms, we find the patient complaining of murmuring and ringing in the ears.‡ Of the organic diseases of the labyrinth there is little on record. It

* Vidit Clariss. Dom. Drelincurtius Tumorem steatomatis consistentia pugnique magnitudine, cerebrum et cerebellum inter, eo præcisè loco ubi conarium utrique substeritur choroidis plexus alæ, spatio semestri a sensibili læsione, cæcitatem primo, surditatem subinde, omnium denique sensuum et functionum animalium abolitionem et necem ipsam intulisse." Bonnet. vol. i. p. 123. ob. 53. In Sandifort, Obs. Anatom. Path. tom. i. p. 116., there is an instance in which the auditory nerve had a cartilaginous tumour adhering to it.

† F. Hoffmann. Consult. et Respons. Cas. xxxix. We must not, however, take his reasoning after what we have seen of the structure of the ear, that the viscid pituita, separated in the concha, cochlea, and labyrinth, resolved into halitus endeavouring to escape, produces the susurrus et tinnitus aurium.

‡ Hoffmann. Med. Consult. Boerhaave. The sympathy is sometimes exerted in a contrary direction. *Sauv.*

would appear, that the fluids become often so altered in their consistence as to prove an absolute destruction to the organ. Mr. Cline found in a person deaf from birth, that the whole labyrinth was filled with a substance like cheese. A disease of the auditory nerve, like that of the retina in the gutta serena, is no unfrequent complaint.*

Deafness, in acute fever, is a good sign; because, say authors, it argues a metastasis of the morbific matter. We should rather say, because it argues a diminution of the morbid sensibility of the brain.† But the surcharge of the vessels of the brain or of the auditory nerve will also produce deafness and unusual sensations in the ear; as in suppression of the menses and hæmorrhoids, in surfeit, &c., in which cases it is often preceded by vertigo and head-ach.

There occurs a very curious instance of analogy betwixt the ears and eyes, in the following cases:—"A certain eminent musician, when he blew the German flute, perceived at the same time the proper sound of it, and another sound of the same rhythm or measure, but of a different tone. His hearing seemed thus to be doubled. It was not an echo; for he heard both sounds at one and the same moment: neither were the sounds accordant and harmonious, for that would have been sweet and pleasant to his ear. Having for several days persisted in his attempts, and always been shocked with this grating sound, he at last threw his flute aside. The day before he first became sensible of this strange affection, he had imprudently walked in a very cold and damp evening, and was seized with a catarrh in the right side. Whence, probably, it arose that the natural tone of that ear was altered: the sound appeared more grave, and dissonant from that received by the left ear. Having recovered from the catarrh, the distinct hearing of his ear was restored."

Sauvages, who relates this case, subjoins another:—"Very lately," says he, "a foreigner came for advice in a similar situation. He complained, that when any person spoke to him, he heard the proper sound of the voice, and at the same time another sound accompanying it an octave higher, and almost intolerable to him. As it must have happened, that, if the accompanying sound had preserved the true octave above the voice, and been synchronous with it, the ear would have received them as one sound, and been pleased with their concord, it is probable that the accompanying sound was not in unison with the true." Sauvages, vol. iii. p. 352.

* Dysecœa (atonica) sine organorum sonos transmittentium vitio evidente. *Cullen.* Cophosis *Sauv. Cophosis* a *Paracusi* distinguitur ut *amaurosis* ab *amblyopia* respectiva. *Sauv.*

† But the difficulty of knowing when the deafness is the result of disease, or malconformation in the parts transmitting the sound to the nerve, and when in the brain and nerve, has led to more uncertainty and confusion with regard to the species and varieties of the disorders of the ear than in the eye, where the transparency of the humours assist in the definition.

OF THE NOSE AND THE ORGAN OF SMELLING.

OF THE SENSE OF SMELLING.

Smelling seems to be the least perfect of the senses. It conveys to us the simplest idea, and is the least subservient to the other senses. The sensation it presents to us we can less easily recall to memory; and the associations connected with it are less precise and definite than those of the senses of hearing and seeing; finally, we should lose this sense with less regret than any other.

Animal and vegetable bodies, during their life, growth, putrefaction, and fermentation, and, most probably, all bodies whatever, are perpetually giving out effluvia of great subtilty. Those volatile particles repelling each other, or diffused in the atmosphere, are inhaled by the nose, and convey to the pituitary membrane of the nose the sensation of smell. Even in the outward form and structure of the nose, there is a relation to the exercise of this sense; the lateral cartilages of the nose, or those which form the nostrils, possess a degree of elasticity adapted to preserve the passage open and free. They have muscles adapted to move them, to expand them when greater freedom of respiration is required, and to contract them in order to diminish the stream of air, and to give it more force to penetrate to the upper cavities of the nose. The cartilage which joins to the septum of the nose is also flexible and moveable by muscles, which curve the nose or draw down the point; thus, in smelling, the air, which in ordinary respiration passes freely backwards, is directed upwards to the æthmoid bone; these cartilages perform another office in giving that flexibility to this prominent feature, which enables it to elude injuries and at the same time protect the bones of the nose: but their chief use is in connection with the sense; for it may be observed, that when we draw the air in, in smelling, the nostrils are compressed, which gives more force to the air received, and at the same time the direction of the stream of air is changed. When we breathe with the nostrils stationary or expanded, the air passes directly backwards, but when it is drawn in, in smelling (the nose being drawn down), a direction upwards is given to the stream of air, so that it is made to circulate about the cells of the æthmoid bone, where the olfactory nerve is expanded.

Immediately within the nostrils, there are two cavities separated by the bony partition, which has been already described in treating of the bones. These cavities enlarge as they proceed inward, and open backward into the throat, and, consequently, communicate with the mouth. They extend upward and sideways into the cells of the bones of the face; and the pituitary membrane is extended over the surfaces of these winding passages, and over the irregular surfaces of the nose, formed by

the projecting cartilages of the æthmoid and lower spongy bones; which, also, have already been sufficiently described.

The cavities of the nose lead into many cells in the bones of the face, which, though not the immediate seat of the sense, are subservient to the organ by permitting a circulation of the air, and thus carrying the effluvia into contact with the nerve. No doubt these cavities are also useful in giving vibration and tone to the voice. The cavities of the nose are continued upwards into the frontal sinuses, and into the cells of the æthmoid bone; backward and upward into the sphenoid sinus; and upon the sides into the antra Highmoriana or sinuses of the upper maxillary bones.

The membrane covering the surface of these bones is called the MEMBRANA SCHNEIDERIANA, the mucous or pituitary membrane. It is of a glandular structure, or is lubricated by the mucus discharged by the follicles on its surface. This secretion on the surface of the membrane, is to defend its delicate and sensible structure from the effects of the air, while it preserves the sensibility of the surface and the delicate expanded nerve. It seems of a nature to allow the effluvia to penetrate it.

A very particular provision has been made against the too powerful effect of smells while the membrane is inflamed, and, consequently, in a state of great sensibility. When the membrane is inflamed, the secretion is altered, and the effluvia does not penetrate, nor does it affect the nerve in its state of extreme sensibility.

We have already described the course of the first pair of nerves or the olfactory nerves, and also those branches of the fifth pair of nerves which are distributed to the membrane of the nose. These, it were superfluous to recapitulate here. The olfactory nerve alone is the organ of smelling, and the branches of the fifth pair bestow merely common sensibility to the membrane.

I have traced branches of the fifth nerve into all the cavities of the face, and we feel that they possess sensibility. In applying volatile salts to the nostrils, we can distinguish a painful sensation to rise into the frontal sinuses different from the sense of smelling. When the root of the nose has been broken in and the cavity opened, experiments have been made by sending effluvia upwards into the frontal bone, and no sense of odours was experienced: but when they were admitted downwards to the æthmoid bone, the first nerve was affected, and the sense exercised. This sensible and nervous membrane, being also glandular and secreting, is very vascular; and this vascularity, this glandular structure, and its exposed state, make it liable to frequent disease: and, when diseased, when tumours and polypi form in it, we must never forget the extreme thinness and delicacy of the surrounding bones, which, when they are either pressed upon by tumours, or have their membranes eroded, are soon totally destroyed. It is with manifest design, that this organ, which so particularly admonishes us of the effluvia diffused in the air we breathe, should have been placed in the entrance to the canal of the lungs. It is, in some measure, a guard to the lungs, as the sensibility of the tongue guards the alimentary canal. That the humidity of the membrane either preserves the sensibility of the nose, or is a solvent, in which the effluvia dissolving affect the nerves, is evident; for the sense is lost when the membrane becomes dried. The sensibility is also af-

fected in various ways by too abundant a mucous discharge, or by an alteration of its natural properties; by the infarction and thickening of the membrane, as in ozæna; by obstructions preventing the current of air through the nose, as in polypi, &c.

The acuteness of sensation in this organ is most probably lost by our habits, by our relying on other senses, by the incessant application of artificial odours to the organ. Those who have believed in the variety of the human species, and the approximation of some tribes to the brute, dwell much on the acuteness of sensation enjoyed by negroes, and their wider nostrils.*

There is nothing more curious than the spontaneous exercise of the organs of the senses. Thus we have bad taste in the mouth, ringing in the ears, sparks of fire before the eyes, when there has been no outward impression made upon the organ; and so have we rarer examples of disease putting even the organ of smelling into exercise. A young gentleman, a student, was attacked with a complaint in his Schneiderian membrane, which changed the nature of its secretions. During this disease he was assailed with the most disagreeable odours, a circumstance not so uncommon; but the unpleasant exercise of the sense was sometimes relieved by his experiencing the most delightful and fragrant effluvia, which were not in existence, but proceeded either from the spontaneous operation of the organ of sense, or from morbid irritation upon it.

OF THE MOUTH, SALIVARY GLANDS, THE ORGAN OF TASTE, &c.

OF THE MOUTH AND TONGUE.

The mouth is that cavity anterior to the velum or fleshy palate; the posterior cavity is the fauces; the mouth is for mastication and speech, the posterior cavity is a common passage, admitting the food to be conveyed into the œsophagus, and the air to be drawn in from the nostrils into the trachea.

The lips and cheeks are formed of the skin and reflected mucous membrane, with muscular fibres intervening to give them pliancy and motion, and with minute glands to discharge the moisture on their inner surfaces.

The glands of the lips are called *glandulæ labiales*, and are very numerous; those of the cheeks are called the *glandulæ buccales*.

OF THE TONGUE.

The BODY of the tongue consists of muscular fibres, with intermingled fat and cellular membrane, nerves, and blood vessels.

* *Pallas* says, the Calmuck, by applying his nose to the hole of a fox, or any other beast, can tell whether he be at home or not.—See *White of Manchester*.

The BASE of the tongue is that part which is backward, and is connected with the os hyoides: the apex is anterior.

The surface applied to the roof of the mouth is called DORSUM. On this surface there is to be observed a middle line, dividing the tongue into two lateral portions; a division which is very accurately preserved in the distribution of the blood vessels and nerves of either side. On the dorsum, towards the base, the surface is rough with the papillæ maximæ and foramen cæcum Morgagni.* These papillæ are like small glands seated in little superficial fossulæ, so that their broad mushroom-like heads alone are seen; but they are connected with the bottom of the fossulæ by short stems or necks. This is considered as a glandular apparatus. The foramen cæcum is, in truth, only an enlarged apparatus of the same kind, for, in the bottom of this foramen, many glandular papillæ stand up; and in its bottom small foramina have been observed, which are generally conceived to be the mouths of small salivary ducts. Morgagni himself, however, seems only to have seen a small duct opening into this foramen in one subject of many which he examined. In *Haller's opuscula* there is a dissertation on the *Ductus Coschwizianus*, which was supposed to carry the saliva from the sublingual gland to the middle of the tongue, and also into the throat, but it turns out to be a vein only. It is curious to observe the necessity the author discovered for these ducts, when he thought he had found them.† The secreting mucous surface begins here, towards the root of the tongue, to resemble the glandular structure of the œsophagus, which, by bedewing the surface of the morsel, fits it for an easy passage through the gullet. This roughness of the root of the tongue is, at the same time, a provision for the detention of the sapid particles, and consequently prolonging of the sensations of taste.

The PAPILLÆ of the human tongue are divided into four classes. 1. Those larger papillæ upon the root of the tongue are the truncatæ; and they are often studded on the dorsum of the tongue in a triangular form. 2. The fungiformes are obtuse papillæ found more forward on the tongue; they are little hemispherical tumid papillæ, with an obtuse surface. 3. The latter are interspersed among the third division, the most numerous and universally prevalent papillæ, viz. villosi or conoideæ; they are, as Sœmmerring says, of various forms, angular, conical, obtuse. 4. The vaginatæ are the more important papillæ, however; they are endowed with peculiar sensibility to sapid bodies; are to be distinguished by their superior redness and brilliancy, and are placed upon the point and edges of the tongue.

The tongue is invested with the cuticle and rete mucosum, like the skin in other parts. The lower surface of the tongue is similar to the general lining membrane of the mouth, being a soft villous and secreting surface. It is reflected off upon the bottom of the mouth, where it forms the FRENULUM LINGUÆ. This ligament seems evidently intended to limit the motion of the point of the tongue backwards. A very false opinion has prevailed, that the shortness of this ligament, or its being conti-

* Adversar. Anat. VI. Animad. XCIII.

† Vater, who injected these ducts, found them terminating in a gland near the os hyoides; and the opinion was, that they had even a connection with the thyroid gland. Heister was of the same opinion.

nued too far forward toward the point of the tongue, prevents the child from sucking. The tongue, as I conceive, would sufficiently perform the necessary action on the mother's nipple, although its lower surface were universally adhering to the bottom of the mouth. But, observe the bad consequences which may arise from yielding to the obstinate importunity of the nurse, and cutting this frenulum. The ranine vein or artery which runs near it may be cut, and the child will continue sucking and swallowing its own blood; and children have actually died, and the stomach has been found distended with blood! But there is another more dreadful accident from this cutting of the frenum linguæ. A child, says M. Petit, whose frenum had been cut almost immediately after its birth, was suffocated and died five hours afterwards. They believed that the operation was the cause of the child's death; they sent for me to open the body. I put my finger into its mouth, and I did not find the point of the tongue, but only a mass of flesh which stopped up the passage from the mouth into the throat. I cut up the cheeks to the masseter muscles, to see what had become of the tongue. I found it turned like a valve upon the fauces, and the point actually swallowed into the pharynx. "Some time after," continues M. Petit, "I was called to the child of Mr. Varin, Sellier du Roy, whose frenum they had cut two hours after its birth, and who, a little after, had fallen into the same situation with the child I have now mentioned, and was nearly suffocated. My first care was to introduce my finger: the tongue was not, as yet, entirely reversed into the throat. I brought it back into the mouth; in doing which, it made a noise like a piston when drawn out of its syringe." M. Petit waited to find the effect of its sucking, and after hearing the action of deglutition for some minutes, the child fell again into the same state of suffocation. Several times he reduced the tongue, and at last contrived a bandage to preserve it in its place; but, by the carelessness of the nurse, the accident recurred, and the child was suffocated during the night. There can be no better illustration of the use of the frenum linguæ.

OF THE SALIVARY GLANDS.

The sources of the saliva are very numerous: the parotid or superior maxillary glands, and sociæ parotidis; the inferior maxillary or submaxillary glands; the sublingual glands; and (according to the opinion of many) the glandular follicles of the root of the tongue, the palate, and even the buccales and the labiales, or glands of the cheeks and lips, are also to be enumerated, as sources of saliva. But the chief source of the saliva is in the proper salivary glands.

The PAROTID GLAND, as its name implies, is that which lies near to the ear. It is the largest of the salivary glands; and it is of much importance for the surgeon to observe its extent and connections. A great part of it lies before the ear, and betwixt the ear and jaw. It extends over the masseter muscle, and upwards to the zygoma. But there is also a great part of it which lies below the tip of the ear, and betwixt the angle of the jaw and the mastoid process. Its surface is unequal, and composed of little masses or lobules of gland, united by a cellular membrane. The duct of this gland was discovered by Needham, and after-

wards by Steno: it is very often called Steno's duct. When it is injected with quicksilver, the branches are seen distributed in a most beautiful and minute manner amongst the lobuli of the gland, like the branching of veins. These branches have a direction upward from the gland, and unite into a trunk, which passes from the upper part of the gland across the cheek over the origin of the masseter muscle: it then pierces the buccinator muscle, and opens upon the inner surface of the cheek, opposite to the second dens molaris. This duct has strong white coats; but, although the mouth of the duct is very small, the duct itself is dilatable.*

The SOCIA PAROTIDIS is a small gland, not constantly to be found, seated on the upper side of the duct of the parotid gland, and just under the margin of the cheek bone. It opens by a lesser duct into the greater duct of Steno. Sometimes, however, instead of one considerable gland, there are several small ones, seated in the course of the great duct, and opening into it by several minute ducts.

The SUBMAXILLARY GLAND is of a regular oval figure, and is seated under the angle of the jaw; it lies under the platysma myoides on the tendon of the digastric muscle; it is defended by the angle of the lower jaw, where it is generally connected with or involves the root of the facial artery. It is regularly lobulated; and its duct passes forward between the genio-glossus and mylo-hyoideus, and under the sublingual gland. The openings of the submaxillary ducts, or ducts of Wharton, are very easily distinguished. They open under the tongue very near each other, on each side of the frenum linguæ; so that they appear as if tied down by the frenum. When these are excited to discharge their fluids, they become a little erected; their open mouths are seen distinctly, and even the tortuous course of their canal in the bottom of the mouth may be seen.

The SUBLINGUAL GLAND is of a flat and elongated form; it lies close under the tongue between the genio-hyo-glossus and mylo-hyoideus muscles. It is the smallest of the three great salivary glands. The two sublingual glands, stretching close under the tongue, are separated from the cavity of the mouth only by the membrane of the mouth. The duct of the sublingual gland opens into the duct of Wharton at the same time that it opens by small lateral ducts, with loose pendulous mouths, upon the lower surface of the tongue.

The *glandulæ molares* are seated betwixt the masseter and buccinator muscles: they properly belong to the class *buccales*. These are small glands, in some measure incorporated with the cheek. The *glandulæ labiales* are more distinct, and can be insulated by dissection: they are round and flat, and sunk in the substance of the lips. All these glands secrete into the mouth.

From the general surface of the lips, tongue, cheek, and palate, there is a fluid exhaled. This exhaling surface and all those glands are excited to action by the same stimulus, the excitement of the morsel in the mouth. The saliva moistens the surface of the mouth, assists in manducation, prepares the food to be swallowed and acted upon by the stomach, and accelerates digestion. As the mouth is an exhaling sur-

* A friend of mine having introduced a silver tube into the salivary duct to cure a fistula, it slipped in and was lost; that is, it was necessary in the end to cut it out by an operation near the angle of the jaw.

face, so is it an imbibing and absorbing surface. Calomel may be rubbed upon the mouth so as to salivate.

VELUM PALATINUM; UVULA; ARCHES OF THE PALATE; AND AMYGDALÆ.

The VELUM PENDULUM PALATI is the vascular and fleshy membrane, which, hanging from the bones of the palate, divides the mouth from the fauces. It is not a simple membrane, but has betwixt its laminæ many glands, which open upon its surface by little follicles, and it is thickened and strengthened by muscular fibres, so that it is more like a fleshy partition, stretching backward and eking out the palate, than a hanging membrane.

The edge of the velum palati is not square, but turned into elegant arches; and, from the middle of the arches of the palate, hangs down the UVULA, so named from its resemblance to a grape. It is a large, soft, and glandular papilla, peculiarly irritable and moveable, having in it muscular fibres, and hanging from the moveable soft palate. It seems to hang as a guard over the fauces, and, by its sensibility, in a great degree governs the operation of these parts. It is also part of the organ of the voice.

The ARCHES OF THE PALATE OR FAUCES descend on each side from the velum palati. They are muscular fibres, covered with the soft vascular and follicular membrane of the fauces.* There are two on each side. These arches stand at some distance from each other, so that the isthmus of the fauces resembles the double-arched gateway of a citadel, or rather the arched roof of a cathedral, with the uvula hanging as an ornament from the central union of four semicircular arches; for the arches which are apart below are joined above.

Behind the soft palate is the cavity of the fauces, and into that cavity there are openings from the nose. The use of the velum is, that, in swallowing, it may be drawn up like a valve upon the posterior opening of the nose; and there being, at the same time, an action of the arches of the palate, the whole are brought into a funnel-like shape, which directs the morsel into the pharynx and gullet. In this action, the direction of the food assists the valvular action of the velum; but, in vomiting, the nose is assailed with the contents of the stomach. The velum also is a principal part of the organ of the voice; it divides the air which issues from the lungs, and directs it either into the cavity of the mouth or nose.

AMYGDALÆ.— Betwixt the arches of the palate, on each side, lies a large oval gland of the size and shape of an almond. These are the tonsils or amygdalæ. The amygdala is a mucous gland; it is loosely covered with the investing membrane of these parts: its surface is seen, even in a living person, to be full of large cells like lacunæ; these communicate; and into these the lesser mouths of the ducts open. On a narrower inspection of the amygdala, we may describe its structure thus: within the arch of the palate, and before the arch of the fauces, there is a fossa of an oval shape, and on the surface of the membrane

* See Vol. I. Constrictor Isthmi faucium and Palato-pharyngeus.

a number of cells open like the mouths of veins. When the arches and the amygdala are dissected out, behind these holes we feel a gland, as it were one solid body ; but on further dissection from behind, the cellular membrane being taken away, instead of one large gland, there are a number of lesser ones. These glands discharge their secretions into the oblique passages just described ; and from these lacunæ the mucus is pressed out when the morsel is pushed backward. From the loose texture, and from its being a vascular and secreting body, exposed to the immediate vicissitudes of weather, the amygdala is often inflamed, and then it impedes the action of the surrounding muscular fibres in the action of deglutition. The use of the amygdala is evidently to lubricate the passage of the throat, and facilitate the swallowing of the morsel ; and, for this reason, are the mouths of its ducts cellular and irregular, that they may retain the mucus until ejected by the action of deglutition. In this operation, the amygdalæ are assisted by numerous lesser glands, which extend all over the arches of the palate and pharynx.

OF THE SENSE OF TASTING.

On the surface of the tongue are to be observed many papillæ*; in which the extremities of the gustatory nerve terminate : they are the organs of the sense of tasting. These papillæ arise from the true skin of the tongue ; they are extremely vascular ; they are covered by the rete mucosum, and a very fine cuticular sheath. These papillæ are to be seen on the point and edge of the tongue, as pretty large vascular soft points which project from an opaque and white sheath. If you take a pencil and a little vinegar, and touch or even rub it strongly on the surface of the tongue, where those papillæ are not, the sensation only of a cold liquid is felt ; but when you touch one of these papillæ with the point of the brush, and at the same time apply a magnifying glass, it is seen to stand erect and rise conspicuously from its sheath, and the acid taste is felt to pass as it were backward to the root of the tongue. The exquisitely sensible papillæ are placed only on the point and edge of the tongue ; for the middle of the tongue is rough and scabrous, not to give the sensation of taste, but to break down the solid morsel against the roof of the mouth, and press the sapid juice from it, so that it may run over the edge of the tongue. The more delicate and vascular papillæ would be exposed to injury if situated on the middle of the tongue. Before we taste, the substance dissolved in the saliva flows over the edges and point of the tongue, and then only comes in contact with the organ of taste.

It would appear that every thing, which affects the taste, must be soluble in the saliva ; for without being dissolved in this fluid, it cannot enter readily into the pores and inequalities of the tongue's surface.

We have already noticed, that by the peculiar form of the larger

* Albinus. Ann. Acad. lib. i. c. xv.

papillæ at the root of the tongue, the fluids lodge, and the gratification of the palate is prolonged. A curious circumstance, in the sense of taste, is its subserviency to the act of swallowing. When a morsel is in the mouth, and the taste is perfect, our enjoyment is not full: there follows such a state of excitement in the uvula and fauces, that we are irresistibly led to allow the morsel to fall backward, when the tongue and muscles of the fauces seize upon it with a convulsive grasp, and convey it into the stomach; it is only then that the measure of enjoyment is full. Were not this appetite of the throat and uvula connected with the action which impels the food into the stomach, the complete enjoyment of the sense of taste alone would satisfy, and would have rendered unnecessary the disgusting practice of the Roman gourmand, who forced himself to vomit that he might resume the enjoyment of eating. But, as it is, the connection of the stomach and tongue is such, that the fulness of the stomach precludes the further enjoyment of the sense of taste. The senses of smelling and taste have their natural appetites or relish; but they have also their acquired appetites, or delight in things which to unsophisticated nature are disagreeable: so that we acquire a liking to snuff, tobacco, spirits, and opium: "Nature, indeed, seems studiously to have set bounds to the pleasures and pains we have by these two senses, and to have confined them within very narrow limits, that we might not place any part of our happiness in them; there being hardly any smell or taste so disagreeable that use will not make it tolerable, and at last, perhaps, agreeable: nor any so agreeable as not to lose its relish by constant use. Neither is there any pleasure or pain of these senses which is not introduced or followed by some degree of its contrary which nearly balances it. So that we may apply the beautiful allegory of Socrates: that 'although pleasure and pain are contrary in their nature, and their faces look different ways, yet Jupiter hath tied them so together, that he who lays hold of the one draws the other along with it.'"

OF THE SKIN AND OF THE SENSE OF TOUCH.

OF THE SKIN.

The skin may be divided, by the art of the anatomist, into four laminæ or membranes, distinct in texture and appearance, and use, viz. the *cuticle* or *epidermis;* the *corpus mucosum*, or reticular tissue; the *cutis vera*, *dermis*, *corium*, or true skin: but from the surface of this last there is separated a *vascular membrane*, below which is the surface of the true skin; lastly, we may enumerate the tela cellulosa as constituting a part of the general integument, giving lodgment to the glands of the skin and to the bulbs of the hairs.

The CUTICLE, or EPIDERMIS, or SCARF SKIN, is the most superficial of these layers: it is a transparent and insensible pellicle which serves,

in some degree, to resist the impression of external bodies on the surface of the body, and to blunt the otherwise too acute sensation of the cutis vera.* In man it is very thin, unless in those parts which are exposed to the contact of hard bodies, as the palms of the hands and soles of the feet. The thickness of the cuticle there, however, is not altogether the effect of labour and walking, but there is even in the early fœtus a provision for the defence of the skin of the feet, by the supply of a thicker cuticle. When the cuticle is drawn from its foot, that part upon the sole is white, opaque, and thick, whilst, in the leg, it is transparent and more delicate.† This is also particular, that by labour or continued pressure on the cuticle it does not abrade and become thin and tender, but thicker, harder, and the part more insensible, so as even to acquire a horny hardness and transparency. Of this we have an example in the hands of smiths and other workmen, and in a remarkable manner in the feet of those who have been accustomed to walk barefoot on the burning sands. It is thus a protection to the foot in a state of nature. But if the skin be too much or too quickly exerted, instead of forming additional layers of cuticle, a serous fluid is thrown out from the true skin, which separates the cuticle in blisters; and this over-action of the skin will throw off the cuticle, as we see to be the consequence of the irritation of plasters or cataplasms, scalding water, exanthematous diseases, erysipelas, and mortifications, &c. When the foot comes to be unnaturally pinched in shoes, the hard leather works perpetually on a point of the toes, and blisters the feet: but if in a lesser degree and longer continued, it excites the formation of cuticle in the skin below, which, thrown outward by succeeding layers of cuticle, at last forms a corn or clavus, and which, like a small nail, has a broad head with a conical point shooting into the tender skin.‡

The cuticle is perforated by the extremities of the perspiring and absorbing vessels, and by the ducts of the glands of the skin, and by the hairs. Indeed, when the small pores of the skin or foramina are examined narrowly, the cuticle is seen to form sheaths which enter into them, and which, when torn out, are like little tubes having a perforated point; for when, by maceration, the cuticle is separated from the skin, as we draw it off we see little processes of the cuticle, which enter into the pores of the skin.

In the dead body the cuticle may be separated by permitting putrefaction to go on, and for this purpose the skin is put in maceration:§ Ruysch separated it by extending a portion of skin and pouring boiling water upon it.‖ Vesalius and Malpighi practised the coarser way of carrying a red hot iron near the skin.

Mr. Cruickshanks enumerates three classes of processes of the cuticle: there appear evidently two. The first lines the pores through which the hairs pass: these are the longest. The second class is easily dis-

* It is unaccountable that so great a man as Morgagni could suppose the cuticle to be the mere effect of air and pressure on the surface of the true skin. Adversar. Anatom. III. 3.

† Albini Annot. Acad.

‡ De clavo pedis, vide Albini Acad. Annot. lib. vi. cap. vi. et vide tab. ii. fig. 1.

§ Santorini Observ. Anat. cap. i. §i.

‖ De hum. C. fabrica, lib. ii. c. 6.

tinguished on the inside of the cuticle which covers the palms of the hands or soles of the feet, or indeed on any part of the cuticle; and they appear in regular order on those parts of the cuticle which correspond with the parallel or spiral ridges of the cutis. these enter into the pores of the true skin. The surface of the cuticle is uniform next the skin; but, on the outer surface, it is rough and squamous. These squamæ are the portions of the cuticle, which, breaking up, are rubbed off; for there is a perpetual change, by the formation of new cuticle under the old, and the abrasion or desquamation of the old surface.

When I say that the cuticle is uniform, I must not forget to speak of the regular lines observable on both its surfaces, and which are especially observable on the tips of the fingers, and which are a very particular part of the organ of touch.

The ulcerative process has no power over the cuticle, so that when the matter of an abscess has reached the cuticle, its progress is stopped until the cuticle is burst by the distension. This is one reason of the greater pain of abscesses in the soles of the feet and palms of the hand, where the cuticle is very strong.*

OF THE STRUCTURE AND GROWTH OF THE NAILS.

The NAILS are naturally connected with the cuticle, for they remain attached to it: in exanthematous diseases, when the cuticle exfoliates, the nails are also pushed off; and in death they both separate from the true skin by maceration and beginning putrefaction. The nails are to give firmness and resistance to the points of the fingers. Although they take a very universal adhesion, it is chiefly from the root that they grow and shoot out to the points of the fingers, to which they adhere firmly. Over the root of the nail the cuticle projects, and under it the rete mucosum is extended; and under this, and defended by it, are the papillæ of the skin.

Like the cuticle, the nails are without vessels or sensation: they are undergoing a perpetual growth, by their roots, and are worn down by labour. When cherished, they grow to an amazing length, and curve a little over the points of the fingers. It was supposed that the nails were formed by the extremities of the tendons, which, extending beyond the flesh, were dried and hardened†; and the celebrated Albinus describes the nail as formed by the conversion of the papillæ which lie under it‡: they are more properly conceived to be a continuation of the epidermis.§

We cannot believe, even on the authority of Albinus, that the nervous filaments which lie fasciculated under the nail are converted into the nail, merely because the under surface of the nail is reticulated like these filaments. For it is evidently reticulated like the soft filaments, in order to give lodgment to them, to have a corresponding surface with them. The nails differ from the cuticle in not scaling or exfoliating like it, but in growing from a root like a hair.

* See Hunter on Blood and Inflam. p. 469.
† Riolanus.
‡ Annot. Acad. vol. i. lib. ii. cap. iv.
§ Winslow.

OF THE HAIRS.

The hairs grow from a bulbous root, seated in the cellular membrane. This bulb is vascular, and has connection, by vessels, with the cellular texture. It consists of a double membrane; the outer is a kind of capsule which surrounds the other, and stops at the pore in the skin, and does not form part of the hair. Betwixt these capsules, there is a cellular tissue, and the space is commonly found filled with a bloody fluid. In the bottom of the inner sac, there is a small body, called monticule by Duverney, from which the hair is seen to arise; and if this is left when the bulb of the hair is pulled out, the hair will be regenerated.

The root of the hairs, says Winslow, is covered by a strong white membrane, which is connected with the skin and cellular membrane. Within the root, there is a kind of glue, some fine filaments of which advance to form the stem, which passes through the small extremity of the bulb to the skin. As the stem passes through the root, the outer membrane is elongated in form of a tube, which closely invests the stem, and is entirely united with it. And many authors agree, that the hair does not perforate the cuticle, but takes from it a vagina which accompanies it in all it's length.*

The hair serves as a distinction in the human tribes. The European has the longest hair, next to him the Asiatic, then the American, and lastly the African.† A common opinion is entertained that hair on the body is a mark of strength; but I have observed our famous boxers, when in high condition, are smooth, fair, and clear in the complexion of their bodies: while men of a dark sallow hue are generally hairy on the trunk and shoulders. Betwixt hair and wool, or betwixt the hair on different parts of the body, there is no distinction in the anatomical structure. In the growth of hair and wool, however, there is a difference. They are both produced annually; but wool is shed at once, and leaves the animal bare, whilst the hair falls off gradually, and the young and the old hairs are together growing at the same time. Hair is of uniform thickness in its whole length; whereas wool is variable in the thickness of its filament:—further, it has been found that the thicker part grows during the warmer times of the season; that it is thicker in summer, and finer in the spring and autumn. This shows us how the fleece becomes coarse and hairy in a warm climate.

RETE MUCOSUM.

The rete or corpus mucosum, or Reticulum Malpighi, lies between the cuticle and surface of the true skin. It is a mucous layer, pervaded by the little fibrillæ passing betwixt the skin and the cuticle. I consider it as a soft bed to envelope and preserve the papillæ of the skin, and as intended to become cuticle in due succession. It was considered, by Albinus, as of a nature adapted to imbibe the fluids through the cuticle, and as a production of the epidermis. Meckel believed it to be only a

* Albinus Acad. Annot. l. vi. cap. ix. and Morgagni Adversar. et Epist. An. iii. § 4.

† Mr. White of Manchester tells us he has seen a lady with hair six feet in length;—a Prussian soldier, whose hair trailed on the ground.

mucous fluid, inspissated into the form of a membrane; and that it was dissolved by putrefaction, while the skin and cuticle remained firm. It is the seat of colour in the skin, and is of a white transparency in the albino, and in the inhabitants of temperate climates. It is black in the negro; copper-coloured in the mulatto; yellow in the Egyptian.* From the experiments of Priestley, on the effects of coloured cloth in absorbing light, we should argue that the blackness of the negro's skin was ill calculated for enduring the heat of warm climates. But it has been, on the other hand, argued that the black colour facilitates the radiation of heat, and that, as the heat of the body is greater than the heat of the atmosphere, the blackness will, upon the whole, tend to preserve the body cool. The rete mucosum changes its shades of colour in Europeans, from the effect of light; but this tanning seems to have no strict resemblance to the permanent colour of the negro's skin. It soon reaches its maximum by the influence of the sun, and soon it wears off again. And this degree of blackness does not attach to the offspring.† When the rete mucosum is destroyed by ulceration, it is imperfectly regenerated, and does not possess its former colour. In a negro, the inner surface of the rete mucosum is blacker than the outer surface; the inner surface of the cuticle is softer and darker than the outer surface.‡ Mr. White argues, that if this blackness were the effect of the sun, that part most exposed would be the blackest. But though I agree with him in thinking that the blackness of the negro is not owing to climate, yet I see this argument of his is incorrect; for it is not the direct influence of the sun which tans; no such effect comes of exposing dead skin; it is the excitement of the living vascular surface in the formation of new matter, or the discharge of colouring matter into the rete mucosum.

While the rete mucosum has its peculiar use of defending the delicate surface of the papillæ of the skin, I conceive it to be undergoing a perpetual change; to be thrown off in succession from the vascular surface of the skin, and in its turn to form the cuticle by its outer layers. The inner surface of the rete mucosum is softer and more pulpy; the outward surface more allied to the cuticle, which gives occasion to Mr Cruickshanks to say it is double.

* Malpighi de Sede Negridinis in Ethiope. It has appeared to me that there was a great deal of colour in the cuticle of the negro, and so Morgagni, "negricante et fusco colore infectas." Adversar. II. Animad. IV. See also Blumenbach de Generis Humani Varietate. The colour of the skin belongs to tribes, and is only in a certain degree affected by climate. Humboldt, Essaie Politique sur la Nouvelle Espagne, observes that climate, which has such an effect on Europeans, has little or none on the Indian complexion; tribes of a temperate climate are darker than those inhabiting a province less cool and temperate. The Indians on the tops of the Andes are as dark as the inhabitants of the plains. Humboldt also asserts (contrary to Volney) that, in the provinces of Spanish America the children of Indians are copper-coloured from the moment of their birth.

† See the Gradation in Man, by Charles White of Manchester. Some have said that extreme cold also tans the skin, as the Laplanders, the Esquimaux Indians, and Greenlanders, are dark; opposed to this, we find the Finlanders and Norwegians fair beyond other Europeans. There is much in the habits of life: a painter will not find his carnation tints amongst the poor, nor in the skin of a Highlander—yet where so pure as in the Highland lady?

‡ For opinions regarding the cause of colour in the skin, see Albinus de Sede et Causa Coloris Æthiopum, Ludg. Batav. 1737.—Haller Element. Physiolog. page 20. —Blumenbach de Generis Humani Varietate Nativa, Got. 1795, page 122., and note.

VASCULAR MEMBRANE OF THE TRUE SKIN.

Under the rete mucosum, and on the surface of the skin, there is a soft vascular membrane, which is still above the porous and glandular true skin. It was first demonstrated by injections in subjects who had died of small-pox, and it is so much strengthened by other inflammatory actions of the vessels of the skin, as to be capable of demonstration. It was at first supposed that this vascular membrane was the rete mucosum successfully injected; but afterwards it was found, that it was distinct from the rete mucosum.* Mr. Cruickshanks conceives that it is cuticle in its state of formation, and that the rete mucosum is in fact a cuticle advancing to the state of perfect maturation. I should rather believe that this is a vascular surface, not changeable, nor losing its vascularity, to be thrown off in form of rete mucosum: but, in itself, the organized surface, which is to secrete the rete mucosum, and which secretion does in succession become cuticle. This vascular surface of the skin, for such I must suppose it, (although it be capable of being separated by long maceration and putrefaction, into something like a distinct membrane,) is the seat of the small-pox pustule, and probably of all other cutaneous diseases.†

Thus there are three laminæ above the true skin, distinguished by their character; the cuticle, the rete mucosum, and the vascular membrane: but as some have divided the rete mucosum into laminæ, Mr. Cruickshanks has separated two vascular layers from the surface of the skin. They who are fond of such minute subdivisions, may thus enumerate five laminæ or membranes, before coming to the porous surface of the true skin.

OF THE TRUE SKIN.

The true skin is the dense, elastic, and vascular membrane which is under these outer layers already treated of. It consists of a net-work of firm filaments, having in their protection sebaceous glands, exhalent and absorbent vessels, nerves, the papillæ or organized extremities of the nerves, and the roots of the hairs. These are sufficient to give it both some substance and firmness. While it has firmness, strength, and elasticity to defend the body, it is also an organized surface, performing important functions in the economy; and the healthy condition of the system depends upon it nearly as closely as on the action of the lungs or of the surface of the intestines.

The skin is dense on the outer surface, while the internal layers are loose, and gradually degenerate into the cellular substance. Our soldiers and sailors have a way of marking their skins with gunpowder or with vermillion, which is indelible. They prick the skin and insert the co-

* Mr. Baynham, who discovered this vascular surface, conceived that he had injected the rete mucosum. Ruysch and others mentioned by Albinus, supposed they had injected the cuticle when most probably they had torn off the vascular membrane, or, as Albinus alleges, Acad. Annot. lib. vii. c. iii. in taking off the cuticle they had torn up the vascular papillæ along with it.

† Of the slough of the small-pox pustule, see Dr. Adams's Morbid Poisons. Appendix.

louring matter into it, where it remains without producing inflammation, and unabsorbed. But this is no proof of the unchangeable nature of the skin as regards its colour, or whatever else may distinguish the nations and tribes of man.*

On narrowly observing the surface of the skin, we find it irregularly porous. Some of these are the ducts of sebaceous glands, which are lodged in the skin. They transmit the hairs also, and are the perspiring, and, probably, the absorbing pores ; or, at least, within these larger pores the absorbing and transpiring vessels terminate. These pores are most remarkable about the nose, mouth, palms of the hands, and soles of the feet. Into these pores of the true skin, as we have mentioned, little sheaths of the cuticle enter, and through these sheaths the perspiring matter must consequently escape : but perspiration is the action of living parts : in death, the action of the perspiring vessels ceasing, the pores of the cuticle are no longer pervious to the fluids, and there is no perspiration or exudation through them, even when the dead surface is exposed to heat, it dries only where the cuticle is off.

OF THE ORGAN OF TOUCH.†

The villi of the skin project above its surface, like the pile of velvet. They vary much in size, and in some places are very much prolonged. They conduct the sensible extremities of the cutaneous nerves to form the organ of the sense of touching‡ ; I see that these sentient filaments are very vascular at their extremities. When the hand is minutely injected, and there seems a general blush of redness over it : when the cuticle is taken off, and we examine the villi with a powerful magnifying glass, their extremities are seen bulbous and red. We know that even in nerves there is no sensibility without blood be supplied, and I look upon this high degree of vascularity as a provision for great sensibility.

These fine filaments are placed in the softest bed possible. Examine the minute ridges of the cuticle, and you may distinguish them to be quite regular ; the ridge which is prominent externally corresponds with a depression or minute sulcus within. In these sulci, or in the interstices of the ridges of the cuticle, there is a soft matter in which the villi lie secure, yet ready to receive the impression made through the insensible cuticle.

Of the nature of the sensation conveyed by the nerves of the sense of touch we are as ignorant as of that conveyed by the other nerves. Some are accustomed to consider this as an inferior sense, for no better reason than that it is more common to the surface of the body, whereas it is the most important, and that which ministers to the other senses and to our necessities most of all :—it is the sense necessary to the existence of every living creature. Nor is it, as they suppose, a universal sense. It is as much limited to the external surface of the body as the sense of vision is to the eye.

* I allude to the ingenious Essay of the Rev. S. S. Smith of the American Philosoph. Society, on the Causes of the Variety in the Human Complexion and Colour.

† Albinus Dissertatio de Sede et Caus. Color. Æthiop. Malpighi, Exercit. de Tact. Organ.

‡ Vide de Papillis Cutis, Albini, Ac. Annot. lib. vi. c. x. and Ruysch.

Nay more, it is that sense which gives correctness to all the others, at least if we are right in attributing the perception of hardness, softness, solidity, figure, extension and motion, to the exercise of this sense. If the sense of touch be that change arising in the mind from the application of external bodies to the skin, then certainly the organ has high exercise, and is of all the senses the most valuable. But it appears to me that these qualities, of hardness, softness, solidity, figure, extension and motion, would be known to us, although we had no nerves in our fingers at all, by what I would call the muscular sense. We may acquire a conception of these qualities by moving our body or our members, by pressing upon an object and feeling the resistance it occasions. Much might be said on this subject, but it is evident that these two senses, of motion or action, and of feeling, must be closely allied and mutually useful to each other.

FUNCTION OF THE SKIN.

The function of the skin has a very extensive connection with the due performance of those of the internal organs of the animal economy.

The perspired matter from the skin consists principally of water and carbon. The carbonic acid produced in the process, is by the union of the carbon with the oxygen of the atmosphere. The perspired fluid holds also in solution several salts, and excrementitious matter of animal substance.

Besides the insensible perspiration, there is an oily exudation from the glands of the skin, which appears to be useful in giving pliancy and softness to the scales of the cuticle. This oily secretion is copiously secreted in the negro; and it appears as a means of protection against the powerful influence of the sun, in as much as it prevents the cracking and breaking of the squamæ of the cuticle. It preserves the skin soft and perspirable. The softness of the negro's skin is remarkable; and this softness and coolness of the skin is observable in all the degrees of propinquity to the negro.

It has been long observed that the surface of the body, immersed in water, gave out bubbles of air. Lavoisier found that this air precipitated lime water. Cruickshanks, Abernethy, Jurin, continued these experiments illustrative of this function of the skin in giving out carbonic acid; but these have been overthrown by Professor Woodhouse of Philadelphia, who proved that the air so collected upon the surface was attracted from the water and not exhaled by surface.

Nevertheless carbon is discharged by the skin, and the quantity is found to depend on the vigour of circulation, and of the constitution; and when discharged from the skin as I have said, the attraction of the oxygen of the atmosphere forms the carbonic acid. Thus the function of the skin is brought to resemble, in the most essential particular, the function of the lungs; and I believe all animal surfaces whatever will be found to partake of this function, the discharge of the useless carbon from the system.

The powers of the human system are, in all respects, superior to that of brutes; and the provision for the human body inhabiting the different climates of the globe, is most particular. It has been proved that

man, for a short time, can support existence in a heat of 260° of Fahr. It is proved, that while he can live in indulgence under the line, he can inhabit a country so cold as to drive away the white bear of the polar regions. A ship's crew have wintered in 76° of northern latitude, and the powers of the living body sustained life while spirits and mercury were frozen.

Although there are experiments by Dr. Fordyce, which prove that animals possess a power of resisting heat independent of perspiration, still, undoubtedly, the free or checked perspiration of the surface is a means of equalizing the temperature of the body. According to the activity of the circulation is the heat of the body, and according to the activity of the circulation is the perspiration in health. By this perspiration, and the change of the perspired fluid unto vapour, the heat of the body is carried off. In a cold atmosphere, perspiration ceasing, the vital heat is retained; in a warm atmosphere, the perspiring action being excited, the heat of the body is prevented, or rather carried off.

The authorities are contradictory in regard to the absorption by the surface, unaided by friction, abrasion, or ulceration.*

The more important function of the surface is to be contemplated in its effect on the general activity of the vascular system, and in the vicarious action which takes place betwixt it, the stomach and intestines, and the kidney and lungs. The similarity of function performed in the lungs and by the skin, would lead us to attend to the injury of the former by the impression of cold on the surface, and the checked perspiration. The fact that perspiration is altered in degree by the progress of digestion, would lead us to attend to the many occasions in which we see the disorders of the viscera effecting changes on the skin; the imperfection of the function of perspiration, when digestion and the function of the viscera are deranged, would lead us not only to mark the symptoms of internal disease on the skin, but to take the means of exciting the latter as a remedy for the former. In the same manner will the secretion of the kidney be influenced by the state of the skin and of perspiration: need I add that the health and strength of the circulation, and of course the health of all the functions, is influenced by the excitement of the skin? Some practitioners take the stomach, and others the bowels, and others the liver, on which they harp continually; let any one take the skin as his object of care, and his practice will have equal success, his cases and facts become soon as numerous, while his connection with general science will be more intimate; and if he introduce his system by showing that health is enjoyed when the various functions, which together form the animal economy, are perfect, and that one function cannot be in health unless the whole be also, he will, in my opinion, have better claims to public favour than any who have yet flourished in it by promulgating doctrines in regard to the functions and diseases of individual parts.

* Rollo on Diabetes, Dr. Currie, Abbe Fontana, Dr. Watson.

THE

ANATOMY

OF THE

VISCERA OF THE ABDOMEN.

INTRODUCTION.

VIEW OF THE SYSTEM OF THE VISCERA, AND OF THE STRUCTURE OF GLANDS.

In this last division of the work we have to comprehend the anatomy and functions of the several viscera of the abdomen and pelvis: we must consider them not only as individual parts, but as connected together, and as forming with the lymphatic and circulating systems of vessels that chain of dependence and relation which constitutes the animal economy. It is necessary to take here a general view of the economy of the intestinal canal and absorbing system, including, at the same time, something of the history of opinions regarding secretion and the structure of glands. It will be understood, that these introductory observations are meant only to combine the several parts, and to prevent that manner of description, which is necessary to accuracy and minuteness, from leading us to consider the several parts as distinct and insulated.

An animal body is never for a moment stationary: the remotest part is in action, and is suffering an incessant change. From the first moment of animal existence a revolution is commenced: we, by slow degrees, advance in activity and strength, and ripen to maturity; but by as slow and as sure gradations we decline to feebleness and infirmities. The more rapidly animals advance in the first stage of their progress, so is their decline proportionally rapid.

But it is not in observing the changes of the animal body from youth to age that the operations of the economy appear the most interesting. It is when we find the living body to consist of parts performing a variety of functions, and these connected and mutually dependent; when we see the circulating fluid throwing out fluid and solid secretions to build up and support the body, which is in incessant and daily decay. Again, our admiration must be strongly excited when we observe the system to consist of fluids and solids, and the existence of the animal to depend upon the balance of different powers, the fluids separating and combining in new affinities, and forming the various secretions; and the solids possessing life and action, and controlling the affinities and influencing the combinations of the circulating fluids. Forgetting that ani-

mation is the essential character of living bodies, that it influences the chymical affinities, and varies the attraction of particles, physiologists have too much endeavoured to explain the phenomena of animated nature by illustrations, formerly drawn from mechanics and hydraulics, and in the present day from chymistry.

In a body in which there is life, there is a perpetual waste; first, by secretions, which for particular purposes are thrown into the cavities, and afterwards carried out of the body entirely, by the excretions of the kidney, by the perspiration from the surface, the exhalation by the lungs, the secretions of the intestines. But more than this, there is a decomposition of the solids of the body which are carried into the circulating fluids, and finally dismissed from the system. Lastly, we observe, that even the powers of muscular motion, nay, the powers of the mind and of the senses, are exhausted by exercise, and renovated through the influence of the circulation. The continued action of a muscle is followed by feebleness, and the continued impression of the rays of light exhausts the retina, so that the object becomes first faint and then vanishes; and these, and all the other powers peculiar to life, are supported by means of the circulating arterial blood.

Since there is waste of the solids and fluids, and exhaustion of the energies of the system, so also must there be a source of supply, and means of renewing its activity, and there must be a perpetual motion in the particles of the living frame. Accordingly, animals have appetites requiring the supply of food and drink, and the calls of hunger and thirst stand in relation to the necessities of the body. When food is received into the first passages, there is thrown out from the stomach a fluid which dissolves it, changes its properties, and is itself essentially altered. The work of assimilation is thus begun. As this converted fluid takes its course through the intestines, it is more and more changed: more nearly assimulated to the nature of the fluids of the animal: and having still additional secretions united to it, particularly the bile, it is by these means purified from the grosser parts, and fitted for absorption. This fluid, which is now called chyle, is absorbed by a particular and appropriate system of vessels, which, from their conveying this white and milky-like fluid, are called the lacteals. The lacteal vessels carry the chyle to the thoracic duct, the trunk of the absorbing system; but not directly; for the chyle is deposited in the mesenteric glands, from which it is again absorbed and carried forward. Or if we suppose these glands to be merely convoluted vessels, its flow is at least delayed, so that it is not at once thrown into the mass of circulating fluids.

We find, then, that the stomach performs digestion, and the spleen, we will venture to affirm, is subservient to it. The secretion of the liver we find to prepare the chyle for absorption, while, at the same time, it is the peculiar stimulus to the intestines. The pancreas pours out a fluid which tempers the acrid bile. The superior part of the intestinal canal absorbs the nutritious fluid or chyle, while the gross remains of the food move on to be deposited in the great intestines. The great intestines are not only receptacles, but form, at the same time, an extensive secreting and absorbing surface useful in the economy.

The lacteal vessels, which take up the chyle, are but branches of the system of absorbents—which is a system consisting of two great divisions,

the lacteals and lymphatics: the first receiving the nutritious fluids from the intestinal canal, and the latter being absorbents, taking up the fluids which have been thrown out upon the cavities and surfaces of the body; and we presume upon their absorbing the solid parts of the body also. Thus the new fluids, rich in supplies, are mingled with those which are fraught with the waste and decomposition of the system. The thoracic duct, the trunk of this system, conveys these fluids thus mingled together into the right side of the heart, where they are received into the vortex of the circulating red blood. These fluids, now agitated and wrought up with the blood in the cavities of the heart, are sent through the circulation of the lungs, and submitted to the influence of their action and the exposure to the atmospheric air.

When chyle is formed in the stomach and intestines, it is observed to consist of albumen, serum, globules, and salts: but the change which it may undergo by its reception into the lacteals, its being deposited in their glands, its mingling with the lymph, its agitation in the heart, have not been observed, though it is natural to suppose, that by degrees it is assimilated in its nature to that of the circulating blood, and does at last become perfectly similar by the operation of the lungs.

By the exposure of the circulating fluids to the atmosphere in the lungs, the carbon of the blood is thrown off, and the blood, resuming its purity, is again suited to circulate in the body.

What is life? we see it in its effects only; we can in no other way comprehend it. Is the blood alive as the solids are? both are alive; that is to say, they have properties which distinguish them from inanimate matter. The term will only be objectionable to those who have defined life to be the effect of the re-union of the several parts composing an animal body. The blood possesses properties while circulating in the vessels distinct from those which it shows out of the body; and these do not depend on the agitation and incessant motion, nor on the degree of heat, nor on any similar circumstance, but apparently on some secret influence which the vessels exert over it.

There are produced from the blood a variety of fluids by organs which are called glands, and the formation or separation of these fluids is secretion. But the solid parts of the body ought to be considered as secretions equally with the matter which flows from the ducts of glands. For there is formed and deposited from the blood, during the round of its circulation, bone to support the incumbent weight of the body; muscular fibre, to give it motion: nervous matter giving it sensibility, as well as all the other variety of solids and fluids. The only difference betwixt these solid depositions from the blood and the glandular secretions, is, that the former are still within the influence of the vascular system, and that they are decomposed and re-absorbed, conveyed again into the mass of circulating fluids before they can be finally expelled from the body, while the latter are poured into receptacles, which make their exit by ducts.

The chymists have observed the division of animal bodies into solids and fluids: but the subdivisions of these are very inaccurate. The fluids they have distinguished into three classes: 1st, Recrementitious humours, which go to nourish and support the body: 2dly, The excrementitious fluids, which are carried out of the body by certain emunctuories;

and the 3d are of a compound nature, being partly recrementitious and partly excrementitious. We must observe, however, that the fluids enumerated under these heads show it to be a very incorrect arrangement. The *first* division comprehends the fat, the marrow, the matter of internal perspiration, and the osseous juice. The *second* comprehends the fluids of insensible transpiration, the sweat, mucus, cerumen, urine, fæces. And the *last* division comprehends the saliva, the tears, the bile, the pancreatic juice, the gastric and the intestinal juice, the milk, and the seminal fluid. To attend to their arrangements of the solid parts of animals serves as little useful purpose ; for we find substances unlike in structure and discordant in function.

From this short view of the system we understand how the powers are spent in action, and the fluids exhausted by deposition and secretion, and how essential to life the functions of those parts are which act upon and assimilate the food. It is the consideration of those organs which forms the subject of the first section of what remains of the present volume. As in the consideration of these functions the structure of the glandular organs becomes a chief subject of enquiry, it will be natural at present to consider the opinions which have been entertained regarding their structure.

The peculiar nature of that organization by which the several secretions are formed, has eluded absolute proof by experiment or dissection. It is imagined that there are some organs which do little more than separate the parts of the blood like to the exudation by exhaling arteries. But neither in the exhalent arteries nor in the simple organs can I imagine a mere straining of the blood, but rather that the same principle of activity influences all, and that the several varieties of secretion depend upon an action modified by the living property in the secreting part. The fluids in circulation and the vessels containing them reciprocally affect each other : we know that a change on the state of the circulating fluids will alter the nature of the glandular action, and an excitement of the gland will still more powerfully change the nature of the secretion ; the active power of the solids appearing to be an agent which controls and directs the chymical affinities.

The term gland is applied to certain solid or firm bodies, with regular and smooth surfaces, which are in great number over the whole body. The functions of many of these bodies are known. They are found to have ducts which convey away a secreted fluid ; but in many of them we discover no duct, and can but obscurely guess at their use.

We are struck with the variety of form in the secreting organs. We see a simple surface pouring out its fluids ; or a simple canal into which the arteries throw out their secretion. We find again the secreting vessels and their ducts convoluted and massed together, forming such firm glandular bodies as I have just mentioned ; of which kind are the solid abdominal viscera. In the glandular viscera there are greater varieties in form than in any of the other parts of the body ; but with these variations there is no corresponding change of function. I am of opinion that the forms of the solid abdominal viscera result entirely from their situation. The liver is convex upwards, because the diaphragm is concave ; and it is irregularly concave downwards, because in contact with the duodenum, colon, and gall bladder. The same may be said of the

spleen, the pancreas, the kidney: their form has reference to place, and has nothing further to do with their functions. The form, in short, results from a system of packing more than any thing else.

When we dissect the glands we do not find them to have much similarity in structure. Thus the substance of the liver, the kidney, the testicle, &c. are quite unlike. There is also a very remarkable difference in the length, size, and form of blood vessels passing into the glands, and of the ducts coming out of them.

In considering the opinions of physiologists or anatomists regarding glandular secretion, and the structure of glands, we find, in the first instance, that the old physicians contented themselves with saying that the glands or viscera possessed a peculiar power to select and separate the fluids from the blood. The next class had recourse to hypothesis: they spoke of the separation of certain parts by means of fermentation*, or by a kind of filtering through the pores or vessels of glands; that these pores allowed only particles of a particular size or figure to pass them.† It was opposed to this hypothesis, that the thinner fluids must have run through the organs destined for the grosser secretions. But when a theory such as this is received, no argument nor proof seems necessary to overthrow it. Resting upon authority alone, it stood until it was overturned by the fashion of new doctrines: one equally puerile was raised upon its overthrow.

We observe, says the founder of this theory‡, that wet or oiled paper will only transmit fluid of that kind with which it is previously imbued; it will not transmit the oil when wetted, nor will the water make any impression on the paper when previously oiled. Upon these facts are to be raised a theory of secretion! Betwixt the secreting vessels and the ducts, in the peculiar tissue of which glandular structure consists, there is interposed a fluid of that particular kind which is required to be secreted; and when the blood is driven against this tissue so imbued, no fluid but of a nature resembling that already deposited can be transmitted. By this hypothesis they explained secretion; making it to depend on the attraction and repulsion of the particles of the blood by fluids previously secreted. We may surely leave this class of physiologists accounting for the original deposition of the fluids in the glands without a wish to search with them further into this mystery. Commentators on this theory, by taking into the system the action of the nerves, indicated that they did not altogether forget that the body was alive.§

Another set of physiologists attributed the whole effect of secretion to the velocity of the blood in the glands or secreting vessels‖; others, to the length and curves of the vessels, and their action upon the fluids. Again, others have been satisfied with the round assertion that the vital action was the essential cause of secretion. This must be acquiesced in, while yet there may remain an enquiry as to the structure and the means employed. While a power exists in an animal body, di-

* Van Helmont. Vieussens, &c.

† Charleton, Descartes, Borelli, Verheyn, &c. &c.

‡ Winslow. Helvetius.

§ Conor, Tentamen epistolare de Secretione.

‖ Boerhaave, Pitcairn, &c.

recting its actions, perhaps both in the solids and fluids, and in the mutual influence which they exert, the form, length, and activity of the vessels and ducts give opportunity and time for the operation of that principle upon which the secretion depends.

Let us attend to the observations of anatomists, and to the appearance which the GLANDULAR VISCERA present under the knife.

It is not perfectly clear what the older anatomists meant by the expression Parenchyma; it however saved them the trouble of investigation. They meant flesh, yet not muscular substance, but such as the liver presents. This matter they seem to have conceived to be formed by the blood. Thus Highmore describes the liver to be formed of the blood of the umbilical vein: the opinion originally of Erasistratus.

Previous to the time of Malpighi it is fruitless to trace the opinions of anatomists regarding the structure of glands. He was the first who sought to throw light upon this obscure subject by anatomical investigation, and he made a more rapid progress than has been done by any man since his day. If we take into consideration the difficulties he had to encounter in a new field, and the prejudices of the learned with which he had to combat, his merits will be found greater than even those of Ruysch. The opinions of Malpighi were received by those who, forsaking the authorities of names, saw the importance of the study of anatomy. Ruysch himself gave credit to the opinions of Malpighi in the early part of his life. But Ruysch's more attentive observations being in contradiction to those of Malpighi, his maturer judgment rejected that anatomist's proofs; and with a boldness in which he was never remarkably deficient, he invented a new theory, or at least alleged new facts, and swayed men's opinions with an absolute authority.

MALPIGHI was an Italian, and born near to Bologna. Whilst yet a young man, being sunk under the accumulation of family distress, absorbed in grief, and lost to the consideration of his interest, he received comfort and assistance from his master, who urged him to embrace the medical profession. His progress was rapid. After studying at Padua, he was called to fill one of the chairs in Bologna. He was then solicited by Ferdinand II., Duke of Tuscany, to be professor in the university of Pisa. Here he was associated with liberal men; and now only in his second professorship did he learn to despise the scholastic learning of the time, and betook himself to experiment as the only means by which philosophy could be raised from the oppressive barbarism of the schools. Malpighi and Borelli were associated: they dissected together; they suggested observations to each other; they doubted, and canvassed freely each other's opinions, and were to each other an excitement and encouragement to perseverance and industry. They were supported by government: popular in their teaching, while they collected round them the learned men of the time. This was the origin of the famous Academy del Cimento. Malpighi was, after this, professor in Messene, and died in the Quirinal palace at Rome, of a stroke of the apoplexy*, after having been some time physician to Pope Innocent XII. Malpighi had many enemies, and even some of his colleagues were animated

* Much coagulated blood was found in the ventricles of his brain by Baglivi.

against him with a dishonourable jealousy. Many laughed at his studies and occupations as frivolous and absurd. Something must be allowed for men who had laboured with diligence to become learned; for these, his opponents, had passed their lives in the study of the Arabian writers. With them studies were enforced which held science in subjection; studies which, in place of invigorating, served only to chill and paralyse exertion, and retard ingenious investigation. Even Borelli, but from other motives, opposed and censured some of the dissertations of Malpighi.

Malpighi has been considered as the inventor of this department of anatomy, which the French, curious in distinctions, have called the analytic method. He showed the impropriety of the term Parenchyma, as applied to the substance of glands. He proved that the lungs, for example, (which they also called Parenchymatous) were not fleshy, and had no resemblance to the glandular viscera of the abdomen. He taught, that though glands are smooth on their outer surface, they consist of lobules connected by cellular membrane: and, upon a still more minute investigation, that they consist of innumerable little follicles or sacs; that these are interposed betwixt the arteries which convey the fluids and the excretory ducts going out from them; that the arteries, or the vasa efferentia, after ramifying and encircling these bodies, pierce them and secrete the fluids into them. On other occasions he describes these little glandular bodies as appended to the ramifications of the arteries, like fruit hanging by the branches of a tree.

Malpighi threw in his liquid injections; dissected and examined with the microscope; made careful observations and experiments on living animals; and, lastly, attended in a particular manner to the phenomena of disease. By disease, no doubt, parts swell out and are magnified, and become distinct; but it is not a good test of the natural structure.

Fig. 1.

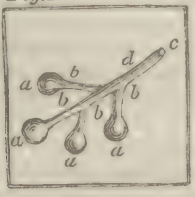


Fig. 2.

Boerhaave's plan of Malpighi's doctrine. *aaa* folliculos glandularum simplicissimarum denotat. *bbb* singularia emissaria cuique utriculo *a*, propri atque in communem canalem excretorium *d*, *c*, suos humores demittentia qui tandem per hujus aperturam *c*, emittantur.

Ruysch studied at Leyden, under Van Horne, and at a very early age attached himself to anatomy and botany. At this time he brought himself into notice by a defence of the professors against one Bilsius, who, although he was learned and acute, had attacked them with all the weapons of a charlatan. Returning to his native country, he was raised

to the professorship of anatomy and botany in Amsterdam. It was here that Ruysch made those discoveries in anatomy, and that wonderful and sudden progress in practical anatomy, which not only raised him above his contemporaries, but has been the admiration of all since his time. Though new and various methods of preparing the body have been discovered since the time of Ruysch, yet there has been no approach to the elegance with which he displayed the structure of minute parts. It has been said, that, while others preserved the horrid features of death, Ruysch preserved the human body in the softness and freshness of life, even to the expression of the features. We must, no doubt, ascribe some part of this encomium to the exaggeration naturally arising from the novelty of the thing. But as to his superiority in the manner of displaying the minute vessels of delicate parts, and his methods of preserving the parts in liquors, transparent and soft, and so as to float in their natural folds, there can be no doubt. Neither can the minuteness and success of his injections be denied: we have too many occasions in which we must resort to the catalogue of Ruysch's museum for the true anatomy to doubt his great success, or to question the truth of those encomiums which have been bestowed upon him.

Kings, princes, ambassadors, and great generals, but more than these, all the learned men of the time, crowded to the museum of Ruysch. We must not blame him, if, whilst others were merely speculating about the structure of parts, he, surrounded by so princely a museum, should simply have laid open his cabinets, and bid them satisfy themselves whether or not he was right. Ruysch's preparations went to contradict the opinions of Malpighi. His injections, pushed more minutely, showed those round bodies which are to be seen in some of the glandular viscera (and which Malpighi took to be little bags into which the secreted fluid was poured) to be merely convoluted arteries. Ruysch taught, that the minute arteries, after making these convolutions, terminated in the beginning of excretory ducts: that there was no substance or apparatus interposed, but that the vessels and ducts were continuous. His opinions being formed upon the strength of more minute preparations, and a superior dexterity of anatomical investigation, few anatomists chose to be outdone, or to acknowledge that they could not see what he saw. This I believe to be one reason of the rapid progress of Ruysch's opinion.

It may be further observed, that it was not in the mere fact of there being follicles, in which Malpighi and Ruysch differed; for the latter conceded that there were hollow membranes, but contended that these were not glands. Their difference of opinion is expressed in the following words of Ruysch: "Adeoque discrepantia inter magnum illum virum et inter me est, quôd ille putat humores delabi in glandulas dictas simplicissimas,—ibi foveri, mutari: Ego puto, quod arteriæ ultimæ succos faciant, et factos ibi deponant."

The opinions of Malpighi and Ruysch have held the schools in perpetual controversy; most anatomists, however, leaning to the authority of Ruysch. There follows these a crowd of French academicians, who, with Boerhaave, may be considered as mere commentators on the original authorities of Malpighi and Ruysch. Some of these argue for secretion by continuous vessels, and contend that the arteries terminate in the excretory ducts; others, that the secretions are made into follicles;

and some, as Boerhaave, insist that both are right in their observations, and in the proofs which they have adduced, that secretion is in part performed by continuous vessels, partly by a more intricate glandular apparatus.

I wish to speak with respect of Bichat, yet I cannot help saying that it is edifying in a way which he did not intend, to find him thus expressing himself. Authors, he says, have occupied themselves a great deal about the intimate structure of glands. Malpighi admits that they are small bodies of a peculiar nature, and Ruysch has established that they are entirely vascular. Let us neglect these idle questions, where neither the eye nor experiment can be our guide; let us begin to study anatomy where the structure of organs comes under the senses. The rigorous advance of science in this age does not yield to these frivolous hypotheses; and so forth. Thus Bichat does not retrace the steps of the mechanical philosophy, nor enter into the science of hydraulics, nor attach himself to the newer school of chemical physiologists, but gives origin to a new school. He boils the liver and the kidney, &c. he dries them, boils them again; observes with all possible minuteness and gravity what floats in scum, what remains behind, what gets soft, what hardens by boiling: he smells and tastes; or he roasts the glands with the same ceremony, and still imagines the while he is deeply philosophical. But all methods bring us nearly to the same conclusion, and certainly explain nothing at all of the nature of secretion.

Of the secretions discharged from the glands it may be sufficient to say, that many of them are destined to be useful to the further operations of the economy; that they are all liable to be absorbed upon any obstruction to their evacuation; and that, as far as experiments on brutes go, all the animal secretions may be even injected into the circulating fluids without greatly disordering the system.*

The blood carried into the glands has nothing peculiar in its appearance and sensible qualities; the idea once entertained, that the blood issuing from the heart immediately commences a separation of its parts for the several secretions, is quite unsustained; and if it deserves a serious refutation, we have it in the varieties to be observed in the distribution of the arteries to the glands; for a different origin of a secreting artery would in that supposition change the secretion.†

In some of the glands the arteries and veins have a peculiar appearance; they are convoluted, and reflected so curiously, as to have given rise to the idea of their preparing the blood for the secretion: thus in the spermatic cord the vessels have been called the *vasa preparantia.* But this convolution of vessels is for another purpose.

Nothing peculiar has been observed in the distribution of nerves to the glands. They are comparatively small. They have been cut, and still the secretion has gone on. As, however, most of the higher and distinguishing properties of life reside in the nervous system, so it is reasonable to suppose that not only the various sympathies and sensibilities

* Haller, by experiments, proved that several kinds of foreign matter may be conveyed into the circulating blood; and Bichat has made the experiment of injecting all the animal secretions into the veins of brutes.

† Bichat has also taken the trouble of examining the blood of the carotid artery, and of the spermatic artery, without being able to observe any difference.

which the glands possess are derived from the nerves, but also that the secretions which they separate from the general mass of blood are owing to an influence of life residing in their nerves. An imperfect knowledge of anatomy, and especially of the connections and relations of the nervous system, gives rise to very useless experiments. Is it not strange that experimenters should think that they cut off nervous energy by cutting through the nerve? This is still proceeding upon an old-fashioned opinion, that the brain secretes the nervous spirits, and the nerves dispense them!

Let us be satisfied with knowing a little. The *life* residing in the gland is an agent controlling the affinities. The liver or the kidney secrete bile and urine, not because they have a certain form, or certain length of vessels, but because the affinities of the constituent parts of the blood are controlled by the living principle in the gland.

As the forms of the parts which throw out secretions have a great variety, it may be useful in this introductory view to point out these varieties, and their appropriate names.* In the first place, although in general language the term gland implies a secreting body, yet this does not follow from the definition of that word. According to Hippocrates, it is a tumid round body, soft, smooth, and shining. Many such bodies, and which we call glands, have no excretory ducts, and do not secrete a fluid; while most secreting parts admit of no such definition. When, again, we admit the definition of authors who have taught their peculiar opinions regarding their structure, we have a still less admissible description. Thus Malpighi defined a simple gland to be "Membrana cava cum emissario;" and Ruysch says, "Glandulæ, non nullæ componuntur ex sola membrana cava cum emissario sed præcipue ex vasis."

These definitions of glands being optional and uncertain, it is necessary to use names appropriated to the several varieties of form in secreting parts. Indeed, the term gland is useless as conveying any knowledge of the structure of which the viscera are composed.

We must observe, however, that there is a division of glands still in use into *conglobate* and *conglomerate*. The first implies a gland simple in its form, the latter a gland having the appearance of an assemblage of several glands.† There is no gland that has not more or less the appearance which is described by conglomerated; that is, consisting of several parts, united by cellular membrane; and the distinction is attended with no advantage.

Acini (the stones of grapes, literally,) form the last subdivision which we observe in the viscera, as in the liver; they are round bodies, not regularly invested with membranes, and which can be teased out into parcels of minute vessels.‡

* The terms acini, cotulæ, cryptæ folliculi, glandulæ, lacunæ, loculi, utriculi, have been almost promiscuously used; being so many names for bundles, bags, bottles, holes, and partitions.

† As the salivary glands and the pancreas. Farther, the lymphatic glands are generally called conglobate glands, being smooth, and apparently simple in their structure; but these, when injected, take exactly the appearance which should naturally be described by the term conglomerate, consisting of many little cavities. These lymphatic glands, belonging to a distinct system, require no farther particular definition to distinguish them.

‡ See farther of the acini of the liver for example.

Cryptæ (implies cells or cavities) are numerous in the body. We have an example of them in the great intestines.* Rusych, denying the definition of Malpighi, says, Crypta signifies a soft body, consisting of vessels not completely surrounded with a membrane, and resolvable by boiling or maceration.†

Folliculi are little bags appended to the extremity of the ducts, into which the secretion is made, and from which it is evacuated by the ducts.

Lacunæ are little sacs opening largely into the passages (as in the urethra), and into which mucus is secreted, lodging there for a time, to be discharged when occasion requires the lubrication of the passage. The best example of this structure is at the root of the tongue, when the glandular textures have been swollen by inflammation.

Finally, we have to recollect that every part of the body secretes; that every surface is a secreting surface; that even that surface which is produced by an incision no sooner ceases to bleed than a secretion begins: and that an ulcer in the skin or flesh becomes by habit similar to those organs, the peculiar function of which is to secrete some matter useful in the system. This fact corrects the notions which we should otherwise be apt to receive of the action of secretion requiring a complicated apparatus, from contemplating the more complicated glandular organs.

OF THE ABDOMEN IN GENERAL, AND OF THE PERITONÆUM.

The abdomen is that division of the body which is betwixt the thorax and pelvis. It is bounded above by the arch of the diaphragm; behind, by the spine; on the sides and fore part by the abdominal muscles; and below, the abdominal viscera are supported by the alæ ilii and the ossa pubis. The abdomen contains the viscera, which are for the purpose of receiving and assimilating the food, and the organs immediately connected with them. Nature, by the classification of the parts in the great cavities, declares a connection of these parts in function, which is never to be lost sight of.

We speak of the *cavity* of the abdomen; but it is an inaccuracy of language; for there is really no cavity. The parietes of the abdomen, viz. the abdominal muscles and peritonæum, closely embrace the contained viscera. To understand what is meant by the cavity of the abdomen, to understand the connection of the several viscera, and the manner in which they lie contiguous, while they adhere at certain points only, we must attend to the peritonæum. But, in the first place, let us notice the outward divisions of the belly.

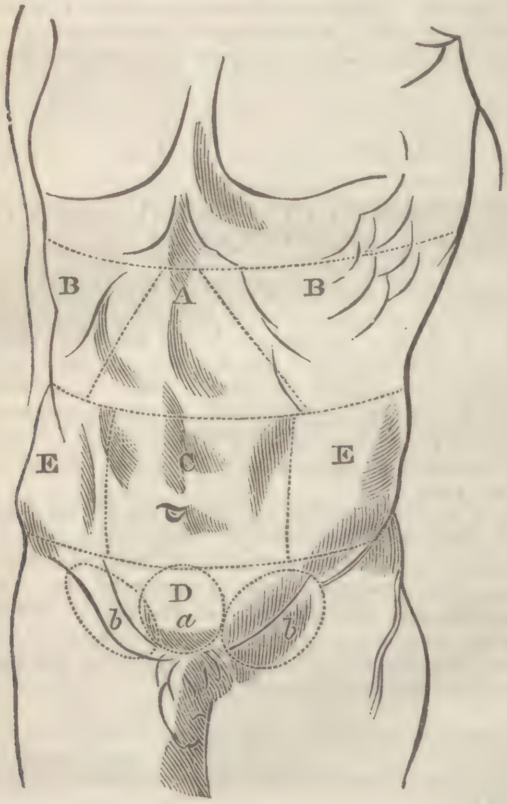
* Ruysch ad Virum Clar. H. Boerhaave, p. 53.

† "Cryptarum vascula possum docere, sed sunt tam subtilia, ut reptatus non possit distingui: tantum circum affusa rubedo per repletionem videtur." (Ruysch ad Her. Boerhaave, p. 77.)

OF THE REGIONS OF THE BELLY.

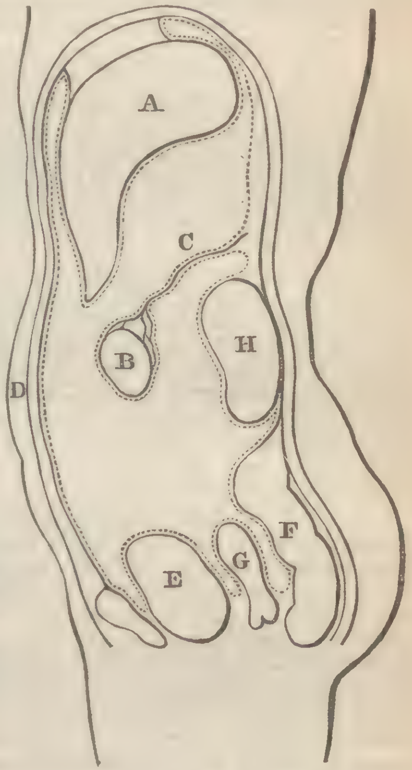
To give greater accuracy to the description of the seat of the viscera, or, perhaps, rather more strictly, to connect the knowledge of the internal parts with the outward marks of the belly, it has been long customary to mark certain arbitrary divisions on its surface, which are called regions.

The EPIGASTRIC REGION (A) is the upper part of the belly, under the point of the sternum, and in the angle made by the cartilages of the ribs. Upon the sides covered by the cartilages of the ribs are the HYPOCHONDRIAC REGIONS, or the right and left hypochondrium (B B). These three regions make the upper division of the abdomen, in which are seated the stomach, liver, spleen, pancreas, duodenum, and part of the arch of the colon. The space surrounding the umbilicus, betwixt the epigastrium and a line drawn from the crest of one os ilii to the other, is the UMBILICAL REGION (C), and here principally are the small intestines. The HYPOGASTRIC REGION is of course the lowest part of the



belly, consisting of the angle betwixt the umbilical region, the spines of the ossa ilii and the pubis (D). The two lateral spaces betwixt the false ribs and the spine of the os ilii, and behind the line perpendicular to the spine of the ilium, are the ILIAC REGIONS (E E), and behind those the LUMBAR REGIONS, or the LOINS: here the kidneys are seated and part of the colon. The hypogastric is divided into three, the pubic in the middle (*a*), and an inguinal on each side. (*b b*)

OF THE PERITONÆUM.



The peritonæum, like all the other membranes of the body, consists of an expansion of dense cellular membrane; yet it is what is called a proper or true membrane; being a white, firm, thin contexture of cellular substance, in which no fibre or striated appearance is to be observed.* By its outer surface it adheres to the adipose membrane, on the inside of the abdominal muscles, and to the surface of the several viscera; its inner surface is smooth, and forms no adhesion while the parts are sound and healthy; its outer surface is looser in its texture, and by the splitting of its lamina it may be traced into the common cellular membrane.

The cellular membrane on the outside of the peritonæum is in some places short, firm, and dense; as on the liver, the spleen, the uterus, and the intestines: but it is longer, lax, and fatty, where it attaches the peritonæum to the muscles and tendons of the abdomen.

The peritonæum has no termination; or it is a sac; yet so curiously is it involved with the viscera, that though we say the viscera are contained in the abdomen, yet, accurately speaking, they are without the peritonæum, and consequently do not lie in the abdominal cavity.†

* The meaning of some anatomists saying that the peritonæum is a double membrane will be seen below.

† The figure represents an ideal section of the abdomen; the edge of the peritonæum is represented by the dotted line.

Let us follow it in its inflections, and suppose that we have opened the sac (that is the cavity of the belly), we find it first expanded on the lower surface of the diaphragm; and at some of the interstices or perforations of that muscle or its tendon it comes in contact with the pleura, and adheres to it by cellular substance. From the diaphragm the peritonæum is reflected off to the liver (A), forming the ligaments of that viscus, and, expanded over its surface, it forms its outer membrane. From the diaphragm it is also sent off upon the œsophagus and stomach, and prolonged to the spleen on the left side (as it is to the liver on the right) so as to form the ligaments of the spleen.

The aorta, the great vena cava, the thoracic duct, and the kidneys, are behind the peritonæum; that membrane being stretched before them. But the intestines are also in the same respect behind this general investing membrane; for it is merely reflected from the spine and psoas muscles, and from the great vessels running down upon the spine, so as to involve the intestines and form their outer coat. (B) As it stretches towards the intestines, it involves the vessels of the intestines in the duplicature, and forms the mesentery. (C)

The peritonæum also lines the abdominal muscles D; it is reflected from the diaphragm upon the surface of the transversalis and rectus abdominis muscles. Here it is united to them by a loose adipose membrane, and from the abdominal muscles it is continued upon the inside of the pubes. From the pubes it ascends upon the bladder of urine E; descends again behind the bladder; and there, making another reflection to mount over the rectum F, and form the meso-rectum, it leaves betwixt the rectum and bladder a particular sacculus; or if the uterus intervene, the peritonæum having descended on the back part of the fundus of the bladder, it is again in a similar manner reflected over the uterus G. The kidney H is behind the peritonæum; but so are the other viscera. The only difference in their relation to this membrane being, that they hang further into its embrace.

From this detailed description we see that the peritonæum has no termination; that it is continued from the surface of the diaphragm to that of the abdominal muscles; from that over the bladder and rectum; from the rectum in the whole length of the intestinal canal; and from the intestinal canal up upon the diaphragm. We see then what is meant when it is said that it is a shut sac; we understand by the cavity of the peritonæum merely the inside of this sac; and that when distended with fluid, the fluid is contained betwixt the peritonæum lining the abdominal muscles, and that part of it which invests or forms the outer membrane or coat of the intestines. This fluid, whether collected there by disease or thrown in by experiment, has no natural outlet, nor does it transude in the living body.*

* We not unfrequently find an accurate general description in authors, but some incorrectness in the subordinate detail, which throws back the ideas of the reader into confusion. Such is the enumeration of the holes or perforations of the peritonæum, " pour donner passage à l'œsophage, à la veine-cave," &c. See Anatom. Chirurg. par M. Palfin. We see that there are no such perforations, that the œsophagus never enters into the cavity of the peritonæum, nor does the rectum pass out from its cavity. This was indeed explained by Fernelius, in opposition to Galen. See a description of the inflections of the peritonæum, by Bartholin.—Specimen Historiæ Anatomicæ Analect. Ob. I.

BLOOD-VESSELS OF THE PERITONÆUM.

As the peritonæum is a membrane of great extent, and investing a variety of parts, its vessels come from many sources. It receives arteries and veins from the mammary vessels; from the phrenic and epigastric vessels; from the lumbar arteries and veins; and from the ilio-lumbales, circumflexæ ilii, renal, and spermatic arteries. It receives nerves from the intercostal, lumbar, and diaphragmatic nerves.

It would appear that disease has given rise to the opinion that the peritonæum has in it many little glands. This is controverted decisively by Morgagni: there are no glandular bodies in the peritonæum.

OF THE USE OF THE PERITONÆUM.

The peritonæum serves as a dense and outer coat to the abdominal viscera; conveys the vessels to them, as in the example of the mesentery; and, having its inner surface smooth and lubricated by a watery secretion, it allows the parts to lie in contact (they being strongly compressed by the surrounding abdominal muscles and diaphragm), and at the same time allows in the intestinal canal a capacity of motion without friction.

There is no internal surface or cavity, as it is called, of the living body, which is not moistened by an exudation from the vessels of the surface. Thus it is with the peritonæum. An exhalation from the extreme arteries bedews its surface, and is again taken up by absorbent vessels; so that it does not accumulate in health, nay, even fluids poured into the abdominal cavity will be taken up by the absorbents.* When the abdomen is opened in animals alive, or recently killed, as in the shambles, a vapour is seen to exhale from the peritonæum, having a peculiar animal odour. Yet we ought not to say that this vapour is collected in the dead body: for before the opening of the peritonæum, or the death of the animal, it is not in a state of vapour, but is condensed into a watery exudation.†

We see the *capacity* of secretion of the peritonæum very well in hernia, where the peritoneal surface will in a very short time pour out a great quantity of serum.

One great use of the peritonæum is to retain the viscera in their place, says Haller; for when it is wounded, they escape, and sometimes with a sudden impetus, which makes it difficult to reduce or retain them.‡

* See Nuck Sialograph. c. ii. p. 27.

"Qua copia in statu secundum naturam secernatur dictu difficile est: ad uncias certe collecta aquula in sani hominis abdomine reperitur. (Kaawn, 543.) In homine, cui sponte abdomen sub umbilico ruptum erat ad quinque et sex libras de die effluebat, ut denique 800 libr. effluxerent." (Journ. de Med. 1757. M. Aug.) This, however, proves nothing of the nature or quantity of the secretion; this has probably been an inflammation and abscess of the peritonæum, which we have seen pours out such a quantity of fluid, thin and serous, as quickly to drop through the bedclothes upon the floor.

† This vapour I have seen arising from the intestines of the human body during the operation for hernia; and also when the omentum and intestines have escaped in consequence of a wound of the belly.

‡ Element. Physiol. tom. ii. p. 380.

But this is not from the want of the embracing of the peritonæum, but from the tendons or muscles which support the peritonæum being cut; for when there is a deficiency in the support given by the abdominal muscles, or their expanded tendons, the peritonæum does not prevent the viscera from being protruded, but easily yields to their forcible protrusion, and forms a sac involving this hernia.

Nor do the processes of the peritonæum, which have received the name of ligaments, nor the mesentery, nor mesocolon, sufficiently resist the prolapsus of the viscera when they have escaped from the pressure of the surrounding muscles. Sufficient example of this we have in hernia of the intestines, in which the mesentery is greatly elongated, or in the displacement of the stomach, or in the prolapsus and procidentia uteri.

The peritonæum which forms the sac of hernia retains little elasticity, and does not shrink into the belly when freed from the outer adhesions; but the general peritonæum will allow great distention, as in ascites, and quickly contract to its former dimensions on the evacuation of the fluid; and so that part of the membrane which invests the stomach and intestines, the bladder of urine and gall bladder, has considerable elasticity, since it suffers these parts to be distended, and again returns to its former dimensions.

The consideration of the insufficiency of the peritonæum to retain the viscera leads us to attend to a circumstance of the greatest importance connected with the viscera of the belly. The abdomen is every where (except towards the spine) surrounded by muscles. Above we see the diaphragm; before, and at the sides, the abdominal muscles; and even below, the parts in the pelvis are surrounded and compressed by the levator ani, in such a manner that the whole of the viscera suffer a continual pressure. This pressure upon the viscera appears to be uniform and constant, notwithstanding the alternate action of the abdominal muscles and diaphragm as muscles of respiration: but it must be occasionally very violent, as during exertions; in pulling, for example, or in straining, as a sailor must do in working of the great guns, or when pulling at the oar, or when balancing himself upon his belly over the yard-arm. And indeed by such violent and general compression of the viscera of the belly, ruptures are sometimes produced, of the worst kind, and followed by an immediate train of urgent symptoms.

The viscera having, in general, delicate outer coats, and no ligaments capable of supporting them, and being very vascular, require the aid of this pressure of the surrounding muscles; and the great venous trunks, which take their course through the abdomen, are in a particular manner indebted for their security to the pressure of the abdominal parietes. We must recollect also the bad consequences which result from the sudden relaxation of the abdomen; as in women after delivery, or in consequence of withdrawing the water of ascites without due compression of the belly; languor, faintness, and even death, are sometimes produced, apparently by the balance of the vascular system being destroyed.

Some good authors, in former times, have described the peritonæum as a double membrane.* This was no farther a mistake than as they

* See Anat. Chirurg. par M. Palfin, tom. ii. p. 35. and note *a*.

considered the cellular membrane, which lies without the peritonæum, as a part of it. It is necessary to recollect this, in order to understand the meaning of their calling the sheath of the cellular membrane, which accompanies the vessels passing out from the abdomen, productions of the peritonæum. The vaginal productions of the peritonæum are the sheaths of the common cellular substance which accompany the aorta and œsophagus into the posterior mediastinum; or which give a bed to the spermatic vessels; or, passing under Poupart's ligament, accompany the vessels of the thigh. They are improperly termed productions of the peritonæum.

The proper productions, or prolongations of the peritonæum are of a very different kind; they are the ligaments and plicæ, the mesentery, mesocolon, and omenta.

OF THE LIGAMENTS AND FOLDS FORMED BY THE PERITONÆUM.

There are certain ligaments and plicæ formed by the peritonæum, which, to enumerate, will carry us again over all the extent of its surface. When this membrane is reflected off to the œsophagus from the diaphragm, it forms, 1. the *ligamentum dextrum ventriculi;* and 2. the *vinculum œsophagi*. In the same manner is formed, 3. the *ligamentum inter œsophagum et lienem*, which we may trace into the omentum majus, presently to be described. From the spleen we may trace the membrane into, 4. the *plica renalis* and *capsularis;* 5. another *plica* or duplicature may be traced from the kidney to the colon, and on the right side, 6. the *plica duodeno-renalis*, viz. from the kidney to the duodenum. When we turn up the liver, we are led to observe the five ligaments to that viscus, to be described in their proper place, and from the liver stretching to the kidney we find the 7. *ligamentum hepatico-renale* still tracing the convolutions of the intestines, and following the *mesentery* or ligament of the small intestines into the *mesocolon*, or ligament of the great intestines, and the *mesorectum* or process of the peritonæum to the rectum; we there see the 8. *plica semilunaris*, which is before the rectum, and behind the bladder of urine.

The young anatomist ought to trace all these processes of the peritonæum, both to comprehend the great extent of this membrane, and more especially to learn the relations of the viscera to each other.

OF THE OMENTA.

The omenta are fatty membranes which hang over the face of the bowels. They are considered as secondary processes of the peritonæum, because they are not formed by the peritonæum reflected off from the spine upon the intestines, as the mesentery is, — it being a primary process; but they are reflected from the peritoneal surface of the stomach and intestines. Anatomists distinguish the *omentum majus*, or colico-gastricum; the *omentum minus*, or hepatico-gastricum; *omentum colicum*, dextrum et sinistrum; and, lastly, the *appendices epiploicæ*.

The OMENTUM, or EPIPLÖON, meaning thereby the great omentum, is a floating membrane of extreme delicacy, expanded over the surface of the small intestines, and attached to the great arch of the stomach and

intestinum colon. Although this membrane be of extreme delicacy and transparency in the young subject *, yet it is much loaded with fat, and appears transparent in the interstices only; and in advanced age it loses much of its delicacy, and acquires a degree of consolidation or firmness, and is often irregularly collected into masses, or adheres preternaturally to some of the viscera.

The omentum majus hangs suspended from the cellular connection betwixt the arch of the stomach and the great transverse arch of the colon; or rather it forms that connection betwixt the stomach and colon. It consists of two membranes, or is as a sac collapsed and hanging from the stomach and colon †, one of the sides being the peritonæum reflected off from the œsophagus and along all the great arch of the stomach, and the other that which comes from the arch of the colon. And further, each of these laminæ may be supposed to consist of two laminæ; for example, where the omentum is formed by the meeting of the peritonæum from the lower and upper surfaces of the stomach; these two uniting form the upper lamina; and where the lower layer of the omentum comes off from the colon, it is also formed by the peritonæum reflected in the same manner from both sides of that intestine; so, with some truth, the omentum is supposed to consist of four laminæ of membranes of extreme tenuity: but these four layers cannot be demonstrated. The great omentum extends from the bosom of the spleen transversely, until it terminates on the right side of the arch of the colon, where the omentum colicum begins.

The great omentum varies considerably in extent.—In a child it is short; in the adult further extended over the viscera: sometimes it reaches only to the umbilicus; sometimes it is allowed to extend its margin into the pelvis, so that in old people it is very apt to form a part of the contents of hernia; often it is wasted and shrunk; sometimes collected into masses, leaving the surface of the intestines.

My reader must now find his way into the *marsupium*, or purse of the omentum, viz. the *porta omenti*, the celebrated foramen of Winslow. It will be found to be a slit betwixt the ligamentum hepatico-colicum and hepatico-duodenalis, being under the biliary vessels and vena portæ. Upon blowing into this opening, in a young subject, three omenta are distended, viz. the *omentum hepatico-gastricum*, the *colico-gastricum*, and the *colicum*.

This opening serves as a communication betwixt the cavities of the omentum and the general peritonæal cavity; but I am inclined to think it is very frequently destroyed by adhesions.‡ As this opening points towards the right side, Dr. Monro thinks it a sufficient reason for introducing the trochar on the right side in the operation of tapping for ascites (contrary to the usual caution of avoiding the liver, which is so often dis-

* "Præterea tenerrimas esse ut nulla membranarum humanarum, retina oculi excepta, æque sit tenera."—Haller, vol. vi. lib. 20. § 1. par. 12.

While its delicacy is remarkable in the young subject, the retiform vessels (vid. Ruysch. Ther. II. Q. V. Spigel. LVIII, &c.) have the fat accumulated in their tract, as if it were thrown up by them to a side; but often, the fat increasing, obscures the vessels.

† Marsupium the common term — See Winslow, IV. p. 352.

‡ Winslow, Duverney, and Haller.

eased in this case); by operating on the left side he thinks the water will not be allowed to flow from the sac of the omentum. It appears to me that it will flow equally well from whatever point of the belly the water is drawn.

OF THE OMENTUM MINUS, OR HEPATICO GASTRICUM.

This is a membrane of the nature of that last mentioned, but in general less loaded with fat. It is extended from the liver to the lesser arch of the stomach. It passes off from the lower surface of the liver at the transverse fossa; from the fossa ductus venosi; invests the lobulus Spigelii; involves the branches of the cœliac artery; and is extended to the lesser curvature of the stomach and the upper part of the duodenum.*

OMENTUM COLICUM.

This is a continuation of the great omentum upon the right side of the great arch of the colon, where it rises from the caput coli; but it seldom extends its origin from the colon the length of the caput coli. It is inflated with the great omentum.

APPENDICES EPIPLOICÆ, OR OMENTULA INTESTINI CRASSI.

These are little fatty and membranous processes, which hang pendulous from the surface of the colon: they are of the same texture and use with the greater omentum and right colic omentum.

We have mentioned that the omenta are double reflections from the peritonæum, and consequently they may be inflated so as to demonstrate them to be perfect sacs. To do this it is not required to puncture any part of them; for, by the natural opening just described, the whole may be inflated in a young subject, and in a healthy state of the viscera.

There is a considerable variety in the form of the omentum of animals†; but still they seem to show the same provision of covering the intestines, filling up the inequalities which arise from the rounded forms of the viscera, and still further lubricating and giving mobility to the intestines.‡ The surface of the omentum, however, seems merely to furnish a fluid exudation like the general surface of the peritonæum; and the idea which has been entertained of the oil or fat exuding is not correct.§

* "Macilentius est, et vasa habet minora." (Winslow. Haller.) Indeed, it seems rather to answer the general purpose of a cellular membrane conveying vessels, than the purposes of the omentum majus.

† Haller Element. Physiol. tom. vi. lib. xx. § 2 and 3.

‡ We must not suppose that because a madman stabs himself in the belly, and there is afterwards found adhesion of the intestines to the wounds, the omentum has not done its office (see Boerhaavii Prelectiones, vol. i. § 45.); no more can we give credit to the tale told by Galen (De Usu Partium. l. iv. c. 9.) of the gladiator who lost part of the omentum, and ever after had a coldness in his guts! At least, we cut out a great part of the omentum from a man without any such sensation being the consequence now-a-days.

§ "Et dum halitu pingui et ipsa obungit et peritonæum." Haller loc. cit. Boerhaave, &c. Morgagni Adversar. III. Animad. VI.

The use assigned to the omentum, of being subservient to the function of the liver, is deservedly neglected.*

OF THE VISCERA OF THE ABDOMEN.

Having understood the nature of the general investing membrane of the abdomen, and what is meant by its cavity and its processes, we take a general survey of the economy of the viscera, before entering upon the minute structure of the parts individually.

The contents of the abdomen are thus enumerated in elementary works on anatomy.

1. The membranous viscera, viz. the stomach, the small and great intestines, the gall-bladder, mesentery, the mesocolon, and ligamentous processes, and the omenta.

2. The solid viscera, viz. the liver, spleen, pancreas, the kidneys, and renal capsules, the mesenteric glands. But a natural order in the arrangement of these viscera is to be preferred.

The organs destined to receive the food, and to perform the first of those changes upon it, which fit it (after a due succession of actions) for becoming a component part of the living body, are the stomach and intestines primarily; the glandular viscera, the liver, pancreas, and the spleen, are subservient or secondary organs. I have been accustomed in my lectures to divide these parts into those which have action and motion, and those which are quiescent, or possessed of no power of contraction. Thus the stomach, intestines, gall-bladder, and bladder of urine (though this belongs to the pelvis) have muscular coats, and the power of contracting their cavities: while the liver, spleen, pancreas, and kidneys, have no muscularity.

This division of the viscera may lead to important distinctions in pathology. During inflammation, it is observed, that though the parts possessing a power of contraction may sometimes lie inactive without pain, yet in those parts when roused to action there is excruciating pain. On the other hand, it often happens that the glandular and solid viscera are the seat of long-continued disease, which is attended only with a dull or low degree of pain; and the anatomist is often struck upon examining the body after death with the wide ravages of a disease which gave no sign during life.

We divide the intestinal canal into three parts; the stomach, the small intestines, the great intestines. The small intestines are subdivided into the duodenum, jejunum, and ileon. The great intestines are subdivided into the cæcum, colon, and rectum.

The stomach is the seat of the digestive process: in the duodenum the food receives the addition of the secretions from the liver and pancreas, and is still further changed; in the long tract of the jejunum and ileon the nutritious part is absorbed; and in the great intestines the foul sediment becoming fæces, is carried slowly forward, suffers a further

* Viz. by supplying a gross oily matter to the venæ portæ.

absorption of fluid, lodges in the lower part of the colon, and then in the rectum or last division of the canal.

From this view it is apparent that each division of the intestinal canal is marked by some peculiarity in its use or function; we must carefully examine their minute structure as individual parts; at the same time that we do not allow ourselves to forget the connection, the relation of the organs, and their economy as a whole. With this intention, following the course of the food, we treat first of the œsophagus.

OF THE ŒSOPHAGUS.

The œsophagus or gullet is a cylindrical muscular tube, which conveys the food to the stomach. It is continued from the pharynx down behind the larynx and trachea and close before the spine, and, continuing its course in the back part of the thorax, it perforates the diaphragm, and expands into the upper orifice of the stomach.

Although with many authors I call it a cylindrical tube, and it may take this form when dissected from the body and inflated, yet during life it lies collapsed with its inner membrane in close contact. It is dilated only by the passing down of the food or drink, and then partially only, since the matter taken into the stomach does not flow as through an inactive tube, but the morsel is transmitted by a succession of contractions of its fleshy coat.

The upper part of this tube is called the pharynx. It may be described as being expanded like a funnel; it is attached to the occipital bone, pterygoid processes of the sphenoid bone, and jaw-bones; and further down it is kept expanded upon the horns or processes of the os hyoides. The lower part of this funnel may be said to terminate in the œsophagus; for although the tube be continuous, and there be no absolute difference in the texture of the pharnyx and the œsophagus, yet the tube is attached in such a manner to the cricoid cartilage as sufficiently to mark the termination of the pharynx and the commencement of the œsophagus. It is here that the tube is narrowest and least dilatable, owing to its connection with the cricoid cartilage. This is a point of the anatomy which must be particularly studied by the surgeon, for here he will meet with difficulty in attempting the introduction of instruments, and here is the seat of stricture. This bag is very fleshy, being surrounded with muscular fibres, which take their origin from the neighbouring fixed points; as the styloid process, the horns of the os hyoides, the thyroid cartilage; by which it is enabled to grasp and contract upon the morsel when it has been thrust by the tongue behind the isthmus faucium. This strong tissue of muscular fibres which surrounds the pharynx is continued down upon the œsophagus in the form of a sheath, which has been called tunica vaginalis.

I believe we can with propriety enumerate no more than two proper coats of the œsophagus, its muscular and internal coat: for that which is sometimes considered as the outer coat, is only the adventitious cellular membrane; and the nervous coat is merely cellular tissue connecting the muscular and inner coats.

The MUSCULAR COAT of the œsophagus greatly surpasses in strength and in the coarseness of its fibres any part of the whole tract of the in-

testinal canal. There may be very distinctly observed in it two layers of fibres; an external one consisting of strong longitudinal fibres, and an internal one of circular fibres. These laminæ of fibres are more easily separated from each other than those in any other part of the canal.* But an idea is entertained that the one or other set of fibres, the circular and internal ones, are for contracting the tube, and the outer ones for elongating and relaxing it. I believe, on the other hand, that they contract together, conducing to one end, deglutition.†

What is called the TUNICA NERVEA is the cellular connection betwixt the muscular and inner coat; it is very lax, insomuch that the muscular coat and the inner coat are like two distinct tubes, the one contained within the other, and but slightly attached. This appearance is presented particularly when the œsophagus is cut across.

The INNER COAT of the œsophagus is soft and glandular; villi are described as being distinguishable on its surface, and it is invested with a very delicate cuticle which dulls the acute sensibility, and prevents pain in swallowing. It in every respect resembles the lining membrane of the mouth. The power, however, which the œsophagus seems to possess of resisting heat depends not on the insensibility bestowed by the cuticle, but is owing to the rapid descent of the hot solids or liquids swallowed; for when they happen to be detained in the gullet they produce a very intolerable pain. This inner coat has an exhaling surface, like the rest of the body, with particular glands to secrete and pour out that mucus which lubricates the passage for the food. These glands suffer ulceration and schirrous hardening, and are a terrible cause of obstruction to swallowing. The inner coat is capable of a great degree of distention; but it is not very elastic, or, at least, contraction of the muscular coat throws it into longitudinal folds or plicæ.

In the neck the œsophagus lies betwixt the cervical vertebræ and the trachea, but is at the same time in a small degree towards the left side. At the bottom of the neck it perforates the membranous fascia, and enters the thorax. Here the surgeon should take good heed of the relation of the tube to the fascia, for I have seen a stricture imagined to be present from an instrument resting on this membranous connection. When the œsophagus has entered the thorax it descends, retiring a little backwards at the same time, and passing behind the bifurcation of the trachea and the arch of the aorta; when it descends farther upon the dorsal vertebræ, it lies rather to the left side; escaped from the aorta, it lies on the right side of it, and as it passes further down it gets more and more before the aorta. This is sufficiently apparent when we attend to the relation of the perforations in the diaphragm for transmitting the aorta and the œsophagus.

* It appears that the œsophagus can be ruptured in two ways; across, by the tearing of the longitudinal fibres; and longitudinally, by the separation of the longitudinal fibres. This, though a rare accident, takes place in violent vomiting or straining to vomit; and, in the first instance, the tearing across of the œsophagus seems to be the effect of the action of the diaphragm on the œsophagus. By this accident the fluids of the stomach are poured into the cavity of the thorax.

† See further of the muscular coat of the intestines. "It was at one time supposed that the muscular fibres of the œsophagus had a spiral direction." See Verheyen, and Morgagni Adversar. iii.

Behind the œsophagus, in the thorax, there are one or two lymphatic glands, which were understood by Vesalius to belong to the œsophagus. What deceived him is an appearance to be observed in these glands. The lymphatics, or the small branches of veins, are generally filled with a black matter, which, extending to the coats of the œsophagus, resemble very much the ducts of the glands going to open into the œsophagus. These glands in the posterior mediastinum are sometimes diseased, and enlarged so as to compress the œsophagus, and to cause so permanent an obstruction of deglutition as to occasion death.

The inner coat of the œsophagus shows so very different a texture from that of the stomach, and this difference is marked by so very abrupt a line; the delicate cuticular lining terminates so abruptly, the one for transmission merely, the other for the lodgement of the food and for digestion, as sufficietly to indicate the different offices performed by the œsophagus and stomach.

OF THE STOMACH.

The stomach is that capacious membranous bag into which the œsophagus delivers the food, and in which the process of digestion is performed. The food of animals is of various kinds, and the form and structure of the stomach varies according to the nature of the food. Animal food affords a rich aliment in a state nearly prepared for supplying the deficiencies of the living system. In such animals as live on flesh the stomach is simple in its form, and possesses little muscular property. On the contrary, vegetable food has a smaller proportion of nutritious matter in it, requiring for its separation a more complicated and tedious process of maceration, trituration, and digestion. Therefore in brutes living on vegetable matters we observe a more intricate system of reservoirs, for separating and preparing the food for the operation of the digesting stomach or true stomach. The human stomach is simple compared with the stomach of the herbivorous animals, but more curiously guarded to retain and fully to operate upon the food than the carnivorous stomach.

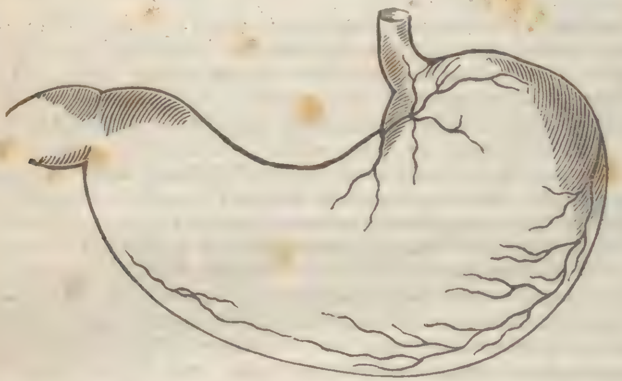
Since I am entering on this subject, I may add, that the length and intricacies of the intestines hold always a relation to the form of the stomach. If the food of an animal be of difficult digestion, and offer little nutriment, as it requires a complicated stomach to prepare its food, so will it require to be carried through intestines long and intricate, that opportunity may be given for the whole nutritious matter to be absorbed out of the mass, and turned to use. But if, on the contrary, the food be rich in nutritious matter, the intestines will be shorter, more direct, and have less of that apparatus intended to delay the course of the contents.

SEAT, FORM, DISPLACEMENT OF THE STOMACH.

The stomach lies under the margin of the ribs of the left side, and chiefly in the left hypochondrium, but stretches into the epigastrium. Its greater extremity is on the left side, in contact with the diaphragm; towards the right, the shelving edge of the left lobe of the liver is betwixt it and the diaphragm. On the lower part it is separated, by the

mesocolon and arch of the colon, from the small intestines; and to the greater extremity the spleen is attached by vessels and by the loose intertexture of the omentum. The stomach may be said to be a conical sac; the extremities of which being made to approach each other, gives it the curve of a hunter's horn, and this is the reason that the anatomist describes these parts; the SUPERIOR or CARDIAC orifice into which the œsophagus expands; the LOWER or PYLORIC orifice, which leads into the duodenum; the LESSER CURVATURE and GREATER CURVATURE of the stomach; and the great bag or extremity towards the left where the spleen is attached, and the inferior or lesser extremity extending to the right side, and in a direction obliquely downwards.

The lesser curvature of the stomach extends from betwixt the two orifices; includes in its embrace the spine, the aorta, and the small central lobe of the liver, while the lesser omentum is attached to it.—The greater curvature of the stomach is the outline of its distended belly, which rises above the arch of the colon, when the stomach is full, and is marked by the course of the gastro-epiploic vessels.



In the fœtus the stomach lies more perpendicular than in the adult. In the adult, when the stomach is distended the lower orifice is nearly on a level with the upper one; but when the stomach is empty, and subsides, it falls considerably lower; so that whilst the stomach lies across the abdomen, it is also tending obliquely downwards. The ensiform cartilage will be found to present to the middle of the stomach; and the lower orifice, when in its natural situation, is opposite to the fossa umbilicalis of the liver: the upper orifice is kept constantly in one place from the stricter connection of the œsophagus with the diaphragm.

Both orifices of the stomach present backward, but more especially the upper one, the lower one being pointed backward and downward. By the distention of the stomach the great arch is extended, the orifices are directed more backward and towards each other, and the greater extremity draws upon the œsophagus. By these means I conceive that there is sometimes produced a difficulty of the stomach discharging its contents when greatly distended, the orifices being in some measure turned both from the œsophagus and duodenum.

The stomach being liable to varieties in its degree of distention, the natural relation of parts must be consequently altered. It ought to be particularly recollected, that in the living body the stomach is supported and bound up by the intestines; so that the great curve is forwards: and the broad anterior surface which the stomach presents in the dead body is turned directly upward, and the inferior downward*. By the collapsing of the stomach, and the consequent falling down of the liver, some have explained the sensation of hunger, conceiving that the uneasy sensation proceeds from the liver being allowed to hang upon the broad ligament.† From the great simplicity of mechanical explanation, physicians have eagerly indulged in them; but it will in general be found, that when they are applied to the explanation of the phenomena of a living body, they lead to erroneous notions.

In describing the human stomach as a conical bag, curved, I speak of what we shall commonly observe in the dead body. But sometimes I have found the stomach divided into two sacs, and more frequently have I seen a contraction in the centre of the stomach, from muscular action. The last two subjects for public demonstration I found divided into two sacs. *Riolan* demonstrated this in 1642. *Schneider* and *Dionis* have given us such instances, and *Morgagni* has expressed an opinion that these were not divisions but only contractions of the stomach. In fact, we meet with a permanent, as well as an occasional form of the human stomach, in which there is a division into two sacs.

Sir Everard Home is of opinion that the cardiac and pyloric portions, thus divided, perform distinct offices.

OF THE COATS OF THE STOMACH.

The coats or membranes forming the stomach are the outer, the muscular, the nervous or vascular, the villous, and the three cellular coats. For some of these subdivisions, however, I see no use, nor are they au-

* Thus the gastro-epiploic artery presents directly forward, and has been wounded by a stab here.

† Winslow.

thorized by the natural appearance of the coats of the stomach. When there is a distinction in texture, structure, of function, and where these laminæ can be separated, we shall consider them as coats; but a mere intermediate tissue of vessels, or the connecting cellular membrane, are improperly considered as distinct tunics.

First coat.—From what has been already said of the peritonæum, it will readily be allowed that the outer coat of the stomach is formed by the peritonæum, a coat common to all the intestines. Were this not sufficiently evident in itself, it might be ascertained by dissecting the peritonæum from the cardiac orifice of the stomach, where it will be found reflected from the diaphragm. This coat is firm, simple in its texture, having no apparent fibrous texture, and smooth on its outer surface, with many minute vessels. Under the peritonæal coat is the first cellular coat, being in fact a short cellular tissue betwixt the peritonæal coat and the muscular coat.

Muscular coat.—The muscular coat of the stomach consists of several laminæ of fibres; less distinct, however, than those of the œsophagus, or, in other words, more loosely and irregularly distributed.*

These muscular fibres of the stomach do not run in an uninterrupted course, but split, rejoin, and form a kind of retiform texture, through which the coats beneath are at intervals discernible. This structure would appear to bestow a greater power of contraction on the stomach. The strong longitudinal fibres which are seen upon the œsophagus form the outer stratum of the muscular coat of the stomach, and they extend from the œsophagus and cardiac orifice in a stellated form along the upper curvature, and downward upon the great end or sacculus ventriculi. Then we have to observe a set of circular fibres, which, forming rings upon the great end, extend over all the stomach, like the circular fibres of the arteries. These fibres do not each encircle the stomach entirely; but while their general direction is circular, they are so interwoven that no one fasciculus can be followed to a great extent. These are called the transverse fibres or stratum; while the deepest layer consists of the continued circular fibres of the œsophagus. These fibres are strong upon the cardiac orifice, and may be presumed to form a kind of sphincter; but they diminish as they are remote from the superior orifice. The lower or pyloric orifice of the stomach, however, is more carefully guarded by muscular fibres; having in the duplicature of the inner coats a distinct circular ring of muscular fibres.

The cellular tissue, being intermingled with the muscular fibres, connects and strengthens them, and gives the appearance of little white lines interwoven with the muscular fibres, and which some have described as small tendons.† There is also to be observed a broad ligamentous band on the two flat surfaces of the stomach towards the pylorus. They are like the bands of the colon, but not nearly so strong or evident. They are formed by the denser nature of the cellular tissue, and more intimate union betwixt the first and second coats.

* The most general opinion is, that there are three layers of fibres in the stomach. Some describe an external longitudinal series; a middle transverse stratum; and again the internal fibres running longitudinally. See Galeati Acad. de Bologne.

† See Winslow, sect. viii. p. 57.

OF THE PYLORUS.*

The pyloric orifice of the stomach deserves more particular attention. When the stomach is distended and dried, and a section is made of its lower orifice, a delicate membrane appears hung across, and which is perforated with a circular opening. When the stomach is hardened in spirits, and a section of this part made, the pylorus is seen to be a duplicature or process of the inner coats of the stomach; and by more particular dissection, it will be found that this circular fold or membrane is formed by the drawing of a more powerful fasciculus of circular fibres which guard this lower orifice.†

OF THE ACTION OF THE MUSCULAR COAT.

Upon considering the weakness of the muscular fibres of the stomach, and the membranous nature of the whole coats, it appears that the general action of the stomach is slow, regular, and by no means a forcible contraction; not an apparatus for triturating the food, but merely giving motion to its contents. But regarding the extreme sensibility of the stomach, and the gradual and regular succession of action, much will be found that is worthy of attention.‡ It would seem that the morsel is sent down into the œsophagus by a succession of actions, preceded by a perfect relaxation; and that when the food arrives at the superior orifice of the stomach, by the same relaxation preceding the contraction, the muscular fibres of the upper part of the stomach yield and receive the food compressed by the œsophagus. Attending to the form of the stomach, we see a provision for the reception of the food into the great sacculated fundus on the left extremity. And here we shall find that there is a greater profusion of vessels for the secretion of the juices of the stomach, and a set of muscular fibres, probably relaxing and yielding to receive the food, and excited to action only when the process of digestion

* *Quasi januæ custos.*

† See H. P. Leveling de Pyloro. Sandifort Thesaurus, vol. iii.

‡ See Haller's Experiments. *Opera Minora*, Ventriculi Motus Peristalticus.

has been in part or entirely accomplished. Often, on dissection, I see the sac or left extremity of the stomach distended, when towards the right extremity it is like the intestine in form. We have proof, that when the food has remained the usual time in the great sac of the stomach, and comes in succession to be presented at the lower orifice, if the stomach be healthy, and the change upon the food perfect, the lower orifice is relaxed, and yields to the contraction of the muscular fibres of the stomach, and the contents of the stomach are passed into the duodenum: but if the food has been of an indigestible nature, it is rejected. The pyloric fibres refuse the necessary relaxation, and by the unnatural excitement, an antiperistaltic motion is produced, and the matter is again thrown into the great end of the stomach, or rejected by vomiting.* There is in the natural action of the stomach a stimulus, followed by a regular succession of motion in its fibres, conveying the contents from the upper to the lower orifice of the stomach. Of this excitement and action we are not conscious; but when the action is disordered by an unusual excitement, the lower orifice is not unlocked, the action becomes violent (the reverse of what naturally takes place), and pain or uneasy feelings are produced. Upon this principle may be explained the nausea and vomiting which take place at certain times after eating, when balls or concretions are lodged in the stomach. While the food lies in the greater extremity, or in the body of the stomach, and the ball or concretion with it, there is no great excitement; but when it has suffered the necessary change, and is approaching to the pyloric orifice, this part, being as it were a guard upon the intestines, is suddenly excited, vomiting is produced, and the ball is thrown into its old place in the sacculus or great end.

An attempt has been made to distinguish the affections of the stomach according as they proceed from the vitiated secretion, or the disordered muscular action. For example, it has been said, if there is pain when the stomach is empty, then it is owing to the secretions of the stomach hurting the coat; if there be pain when the stomach is full, or at regular periods after taking food, then is it proceeding from disordered muscular action. This is settling the whole difficulty on too easy terms. The functions of the muscular fibre and of the secreting vessels are not thus distinct. The motion of the stomach itself, and the secretions into it, are actions conducing to a general result, and nature has secured the end by combining the means; and vitiated fluids poured into the stomach even by its own vessels, are attended with irregular spasmodic pains.

This great sensibility, producing effects almost like intelligence, is apparent in the more common disorders of the stomach. We shall find the meteorismus ventriculi (the great distention of the stomach by flatus) existing for weeks, and yet the food passing in regular course through its orifices. We shall find very frequently food of difficult digestion lying in the stomach and oppressing it for days, while food more recently received may have undergone the natural changes, and have, at all events, passed through the pylorus into the duodenum.

* It would seem that the upper orifice of the stomach has a power of contraction on unusual stimuli being applied. Haller loc. cit. Exp. ccciii.

Owing to the same slow and successive action of the stomach, it often happens that ulceration and scirrhous pylorus, or other obstruction of the lower orifice of the stomach, is attended with pain, nausea, and vomiting, only at stated intervals after taking food; *i. e.* at the time in which the food should be sent into the intestines in the natural course of action.

The muscular fibres of the stomach are excited by stimuli, applied, not to their substance, but to the contiguous coats; and betwixt the delicate surface of the inner coat and the muscular fibres there is the strictest sympathy and connection. The same connection holds in a less intimate degree betwixt the outer coat and the muscular fibres; for when a part on the surface of the stomach of a living animal is touched with acid or stimulating fluids, the part contracts.* The stomach is considered as less irritable than the intestines, because it is alleged that a stronger dose of a medicine is required to prove emetic than to act as a purgative: but we ought to consider that the action thus excited in the intestines is merely an acceleration of their secretions; while vomiting is the interruption of the usual action, requiring such a violent excitement as to invert the natural action.

But there is something more than this: as the function of the stomach differs from that of the intestines, so may the quickness of their action. Thus in the stomach a gradual change is to be produced upon the food, requiring time and a slow degree of motion; but in the intestines there is a greater agitation of their contents, and a quicker action of their coats, to bring the fluids into more general contact with the absorbing surface, and to give greater activity probably to the absorption by the lacteals. I am inclined to think that the stomach is the most irritable part of the body, and susceptible of the most minute distinctions in the nature of the stimuli applied to it.

The phenomena of the living animal, and experiments in those recently killed, sufficiently prove the contractile powers of the two orifices. Experiments have been made which show the powers both of the cardiac and of the pyloric orifices in retaining the contents of the stomach after the œsophagus and duodenum have been cut across. The stomach of a rabbit has been squeezed in the hand after cutting the duodenum, without any of its contents being permitted to escape†; and in similar experiments, the finger being introduced into the lower orifice of the stomach of an animal yet warm, the fibres of the pylorus were found to contract strongly upon it. Upon forcibly compressing the stomach, the food will be made to pass into the œsophagus much more readily than into the duodenum; which is another proof how necessary the natural series of actions is to the relaxation of the pylorus.

Rumination.—As it is found that some individuals ruminate, and that even such a habit may be acquired, it must be right to say a few

* "In ea sede quà tangitur, contrahitur, sulcusque profundus nascitur, et rugæ; cibusque aliquando propellitur ut à sede; contracta fugiat. Minùs tamen quàm intestina ventriculus irritabilis est: hinc emetica fortiora necesse est purgantibus."—Haller.

† See a paper 3d vol. of Sandifort, Thes.

An excellent plate of the Polyrus, given with this Dissertation.—*Morgagni* Adversar. III. IV. de Ventriculi Struct.

words on this subject.—In the ruminating quadrupeds the food passes into the paunch. The paunch consists of a larger and smaller cavity, and from the lesser cavity the food is regurgitated into the mouth, to suffer mastication. When a second time swallowed, it is let into the third cavity, and from the third it passes into the fourth cavity, and from that into the intestines. The human stomach cannot perform an operation so complicated as this. But the different directions which the food takes in the stomach of the ruminant animals, in consequence of the motions of the muscular fibres closing or adjusting the slits of the œsophagus, or the openings of the several bags, proves to us that many silent and curious operations may be going forward even in the human stomach. Something we might suppose would be learned from the feelings of such men as chew the cud; but it happens that the best recorded instance occurred in one, a mere brute in intellect.* Here the morsel was brought up from the stomach by a very slight effort; it was chewed and swallowed; after a pause another morsel was brought up, and underwent the same process, and was swallowed. He ate his food voraciously and without chewing. There is no history of dissection on record except on the authority of Fabricius ab Aquapendente, who found the œsophagus remarkably muscular.

Of vomiting.—When there is an unusual or unnatural irritation on the stomach, or when it is violently stimulated or opposed in its natural course of action, the motion becomes inverted; and drawing by sympathy other muscles to its aid, the contents of the stomach are evacuated by vomiting. Thus where the food takes changes inconsistent with healthy digestion; or when solid matters lodge in the stomach; or when secretions of the duodenum pass into the stomach, or unusual actions are propagated backwards upon the stomach from the upper portion of the canal; or when emetics are taken, which are unusual stimuli; or when there is inflammation in the stomach, which, from giving greater sensibility, produces the same effect with more violent stimuli; or when the coats are corroded or ulcerated;—vomiting is produced. That vomiting may be produced by the inverted motion of the stomach and œsophagus alone, is apparent from experiments upon living animals, where the abdominal muscles are laid open, and from cases in which the stomach has lain in the thorax, and yet been excited to active vomiting.† Again, it is equally evident that, when the stomach is excited to vomiting, there is consent of the abdominal muscles, by which they are brought into violent and spasmodic action; not alternating in their action, as in the motion of respiration, but acting together, so as greatly to assist in compressing the stomach: but at the same time, the action of these muscles, however forcible their contraction, cannot alone cause vomiting; nor has the action of these same muscles any tendency to produce such an effect on other occasions, in which the utmost contraction of the diaphragm and abdominal muscles is required to the compression of the viscera. Many have conceived that vomiting is entirely the effect of the action of the abdominal muscles and diaphragm. Such, for example, has been the opinion not only of J. Hunter, but of Duverney, and of M. Chirac

* By Sir Everard Home.
† See Wepfer de Cicuta Aquatica, p. 68.—Sauvage's Vomitus.

in Hist. de l'Acad. des Sciences, 1700. M. Littre opposed this notion, and contended before the Academy, that the contraction of the diaphragm was the principal cause of vomiting. M. Lieutaud in 1752 supported the idea that vomiting is the effect of the action of the stomach. He found, upon dissection in a patient whose stomach had resisted every kind of emetic, that it was greatly distended and become insensible; and concluded that the want of action in the stomach, and consequent loss of the power of vomiting, was a strong proof of the action being the effect of the contraction of the stomach only. There are other more curious instances of disease of the stomach preventing the muscular contraction in any violent degree, and consequently the absence of the usual symptom of vomiting:—an instance of this kind will be seen in Dr. Stark's work. In my Museum I had a preparation of a stomach, in which the walls had become so thick that they could no longer suffer contraction by the muscular fibres; the consequence of which was that, although the inner coat of the stomach was in a raw and ulcerated state, there was no active vomiting.

There is a very curious experiment by M. Magendie which has much puzzled physiologists. He cut out the stomach of a large dog, and substituted in its place a bladder which he fastened to the œsophagus, and having excited *vomiting*, by pouring emetic solution into the veins, the contents of this bladder were discharged as from the natural stomach. The conclusion has been too hastily formed, that the stomach has therefore nothing to do with the action of vomiting. But it ought to be recollected, that the bladder represents a relaxed stomach, whereas the stomach is muscular and active, and capable of resisting the action of the abdominal muscles and diaphragm, unless there be a consent of the action of the stomach and the action of the muscles of respiration. Thus if we could suppose that a man had a distended bladder for a stomach, whilst he exerted himself forcibly and retained his breath the contents would be discharged. So would they if he lay with his belly over a yard-arm. But no such discharge takes place from the natural body, because the upper orifice of the stomach resists! This resistance does not take place in vomiting; and therefore, I say, the stomach has to do with vomiting, in spite of all the cruelties which have been committed. The lower orifice is contracted, the coats of the stomach are contracted, and the upper orifice is relaxed in the act of vomiting: while the power of ejecting the contents is very principally owing to the violent throws and contractions of the abdominal muscles and diaphragm.

The singultus is the partial exertion of the sympathy betwixt the upper orifice of the stomach and the diaphragm, by which a kind of weak spasmodic action is excited in it, but without a concomitant inverted action in the stomach and œsophagus. It is a convulsive and sonorous inspiration, owing to an irritation of the upper orifice of the stomach and œsophagus, but not exactly of that kind which causes inversion of the natural actions of the stomach. Thus we have the singultus from gluttonous distention of the stomach, from some medicines and poisons, from some crude aliment, or even from some foreign body sticking low in the œsophagus, or from inflammation. The borborigmi and rumination seem to be gentler inverted actions of the upper orifice of the stomach and

œsophagus, unassisted by any great degree of compression of the stomach by the abdominal muscles and diaphragm.

The full action of vomiting is preceded by inspiration, which is a provision against the violent excitement of the glottis, and the danger of suffocation from the acrid matter of the stomach entering the windpipe; for by this means the expiration and convulsive cough accompanying or immediately following the action of vomiting, frees the larynx from the ejected matter of the stomach. But the action of the diaphragm is farther useful by acting upon the mediastinum, which embraces the œsophagus, and no doubt supports it in this violent action.

The subject is very interesting, but I must enlarge no more upon it here.

NERVOUS OR VASCULAR COAT OF THE STOMACH.

What Haller calls the nervous coat, is the cellular structure in which the vessels and nerves of the stomach ramify and divide into that degree of minuteness which prepares them for passing into the innermost or villous coat. It may with equal propriety be called the nervous, the vascular, or the great cellular coat.* Taking it as the third distinct coat of the stomach, it is connected with the muscular coat by the SECOND CELLULAR coat, and with the villous coat by the THIRD CELLULAR coat. Strictly, however, it is the same cellular membrane, taking here a looser texture to allow of the free interchange and ramification of vessels. When macerated, it swells and becomes like fine cotton, but has firmer and aponeurotic-like filaments intersecting it; it can be blown up so as to demonstrate its cellular structure.† It is in this coat that anatomists have found small glandular bodies lodged, especially towards the extremities or orifices of the stomach.

VILLOUS COAT.‡—This is the inner coat, in which the vessels are finally distributed and organized to their particular end. It is of greater extent than the outer coats of the stomach; which necessarily throws it into folds or plicæ. These folds take, in different animals, a variety of forms: but they are simple in man: from the œsophagus they are continued in a stellated form upon the orifice, but form no valve here. In the body of the stomach they are more irregular, sometimes retiform, and sometimes they form circles or squares, but they have generally a tendency to the longitudinal direction. In the pyloric orifice the villous coat forms a ring, called the valve of the pylorus, which, however, has no resemblance to a valve in its form or action. This ring is not formed by the inner coat of the stomach alone, but by the inner stratum of fibres of the muscular coat, the vascular and cellular coats, and the inner or villous coat. The effect of all these coats, reflected inward at the lower orifice, is to form a tumid and pretty thick ring, which appears like a perforated circular membrane when the stomach has been inflated and dried;

* To call it cellular coat, however, would be to confound it with the three cellular coats generally enumerated by authors.

† Winslow, sect. viii. p. 64.

‡ For a highly interesting description of the appearances of the mucous membrane of the stomach and bowels, in health and disease, see HORNER's valuable communication published in the first No. of the American Journal of the Medical Sciences. J. D. G.

but in neither state is its direction oblique so as to act as a valve. It seems capable of resisting the egress of the food from the stomach, or the return of the matter from the duodenum, merely by the action of the circular fibres which are included in it.

In the inner surface of the stomach of those dying suddenly, and who were previously in health, *plicæ* may be observed more or less distinct according to the state of contraction of the muscular coat of the stomach. But in those dying of disease and with relaxed stomach, no folds of the inner coat of the stomach are to be seen. The reason of this the reader should comprehend. The matters contained in the stomach after death, being no longer controlled, enter into chymical decomposition, which extricates flatus, and the gas distends the stomach. This distention removes the plicæ of the inner coat, and indeed changes the whole form of the stomach.

The glands of the human stomach are very small, but in great numbers around the termination of the œsophagus. In this description I am looking to the plate of Sir Everard Home. Brunner described the glands of the stomach as seated on the curvatures. Glands are distinctly to be seen in the stomach of birds and many quadrupeds, and in fishes and serpents.* But it is to Sir Everard Home that we owe the most careful observations on this subject. His lectures on this subject delivered in the College of Surgeons had that grave character of investigation befitting the place, while they possessed an interest beyond example.†

Gastric fluid.—There is secreted into the stomach a fluid, which is the chief agent in digestion. The most common opinion is, that it flows from the extreme arteries of the villous coat in general. When pure, it is a pellucid, mucilaginous liquor, a little salt and brackish to the taste, like most other secretions, and having, in a remarkable degree, the power of retarding putrefaction and dissolving the food. It acts on those substances which are nutritious to the animal, and which are peculiarly adapted to its habits.

It seems to be a peculiarity in the human stomach, that it has a greater capacity for digesting a variety of animal and vegetable bodies. But perhaps the natural power of digesting is diminished as the stomach gains the power of dissolving a variety of substances. In other creatures, a sudden change of food excites the stomach to reject it, and the powers of the stomach are found incapable of acting duly on the aliment, though time so far accommodates the gastric fluid to the ingesta, that the digestion becomes perfect. Mr. Hunter speaks of the power of cattle eating and digesting their secundines.‡ I have seen the membranes coiled in the bowels of a cow; but I too hastily concluded this to be the cause of death. I am corrected by the authority of Dr. Jenner and Dr. Adams. The fact is sufficiently ascertained, that the nature of the digestive process may be so far altered that graminivorous animals may be made to eat flesh, and carnivorous animals brought to live upon vegetables. This throws us back from the simple idea which we should be apt to entertain of the nature of the change produced by digestion, viz. that it is chymical. For we see that the nature of the solvent thrown out from the

* Haller. † These Lectures are now published.
‡ See Observations on Digestion.

stomach, and its chymical properties, may be changed by an alteration in the action of the coats of the stomach. Thus we are baffled in our enquiries, and brought back to the consideration of the living property, which can so accommodate itself to the nature of the aliment.

The gastric fluid has been collected from the stomachs of animals after death, by sponges which the animal has been made to swallow, or which have been thrust down into its stomach, incased in perforated tubes. And, lastly, it has been obtained by exciting the animal to vomiting, when the stomach was empty; for the secretions of the stomach are then poured out unmixed with food.* Although by these means a fluid may be obtained which may properly be called the *succus gastricus*, yet it must contain a mixture of the saliva, and secretions from the glands of the œsophagus and pharynx, with the glandular secretions of the stomach, and the general vascular secretion from the surface of the stomach. It is a fluid, then, upon which the chymist can operate with no hope of a successful or uniform result. And, indeed, chymistry seems no farther to assist us in forming an accurate conception of the changes induced upon the fluids in the alimentary canal, than that the more perfect, but still very deficient, experience of the modern chymist successfully combats the speculations of the chymists of former ages. For example, it was formerly supposed that digestion was a fermentation, and that this fermentation was communicated and propagated by the gastric juice. It is now found that the gastric juice has properties the reverse of this; that it prevents the food from taking an acid or putrefactive fermentation; that it acts by corroding and dissolving the bodies received into the stomach; and that it is itself at the same time converted into a new fluid, distinct in its properties.† It is almost superfluous to observe‡, that the gastric juice has no power of acting upon the coats of the stomach during life; whether this be owing to the property, in the living fibre, of resistance to the action of the fluid, or that there is a secretion bedewing the surface, which prevents the action, it is not easy to say; but more probably it is owing to the resistance to its action inherent in a living part.§

* By Spallanzani.

† The most curious fact is that property of the coats of the stomach, or of the fluids lodging in the coats of the stomach, by which milk and the serum of the blood are coagulated. It has been found that a piece of the stomach will coagulate six or seven thousand times its own weight of milk. This action seems a necessary preparation for digestion, which shews us that the most perfect and simply nutritious fluid is yet improper, without undergoing a change, to be received into the system of vessels. For example; milk and the white of eggs are first coagulated, and then pass through the process of digestion. See J. Hunter, Animal Economy, Observations on Digestion.

‡ I do think it a very self-evident fact, notwithstanding Dr. Adams's taunting manner of quoting these words. See that very interesting work on *Morbid Poisons*, preface, xxxvi.

§ Mr. Hunter is one great authority on this subject, &c.

See also Morgagni Adversar. iii. A. xxiv.

Dr. Adams on Morbid Poisons, preface; and Mr. A. Burns's (of Glasgow) Paper, Edin. Journal, Ap. 1810. Amongst other curious facts stated by Mr. Burns is this, that he has found all the length of the alimentary canal dissolved into a pulpy glutinous mass. I may say that, connected with the discussion, there may enter a question as to what is the cause of a tenderness sometimes to be observed in all the membranes of the body. I have examined the viscera of a negro, where the intestines were particularly tender, but the pericardium and valves of the heart more remarkably so still.

Mr. Hunter supposed it necessary that the animal should be in health, immediately preceding death, in order that the secretion of the gastric juice may be natural and capable of dissolving the dead stomach: but I have found the stomach of children, who have died after a long illness, digested by the secretion of the stomach. See Examples in my Collection.

Of digestion. — By trituration and mastication, and the union of the saliva in the mouth, the food is prepared for the more ready action of the stomach upon it. In the mouth, however, no farther change is induced upon it than the division of its parts. But in the stomach, the first of those changes (probably the most material one) is performed, which by a succession of actions fits the nutritious matter for being received into the circulation of the fluids of the living body, and for becoming a component part of the animal. For now the gastric juice, acting on this fluid mass, quickly dissolves the digestible part, and entering into union with it, produces a new fluid, which has been called chyme, a thick or viscid and turbid fluid. The mass changes its sensible and chymical properties; and when it has suffered the full action of the stomach, by the gradual and successive muscular action of the stomach, it is sent into the duodenum. The food is converted into chyme by the operation of the gastric fluid, by an operation peculiarly animal, a process of life. And the conversion of the food into a new substance is unattended by any chymical change, strictly speaking, if by chymistry we understand the mutual influence of dead matters in forming compounds, or separating and extricating the constituent parts. Animal or vegetable matter in the heat and moisture of the stomach would quickly fall into the fermentations; but the living properties of the stomach prevent this. I speak of the stomach in health; when weak, then the symptom announcing the diminished power is the extrication of gas, or the formation of acids, with oppression and uneasy sensations. The contents of the stomach consist of air, partly swallowed, partly extricated, of the watery secretions of the coats, and of chyme. The stomach being stimulated by fulness, by flatus, and more still by the peculiar irritation of the food prepared by digestion, the muscular coat is brought into action, and the contents of the stomach delivered into the duodenum.

A case is on record which finely illustrates the function of the stomach. A woman was presented in the clinical ward of La Charité to Corvisart, who had a fistulous opening in the left side of the epigastric region, which communicated with the stomach, and through which part of the villous coat of the stomach could be seen, of a vermilion colour, and covered with mucus, and having certain plicæ.

The vermicular undulations of these rugæ of the inner coat of the stomach could be observed. Three or four hours after this woman took food, she felt an irresistible desire to raise the dressings from the fistula. Then flatus was forcibly discharged with the food, which was reduced into a greyish pulp, having neither acid nor alkaline properties. After emptying the stomach, which she washed, by sending through it a pint of infusion of camomile, she found perfect ease. In the morning a small quantity of fluid like saliva, ropy and clear, was found at the orifice.

This was probably the gastric fluid ; it possessed neither acid nor alkaline qualities.

On her death the hole in the stomach was found eight fingers' breadth from the left extremity, or one third of the whole length of the stomach distant from the pyloric orifice.

From this case we learn, 1. that the stomach is subject to a gentle vermicular motion ; 2. that the food received into the stomach is retained three or four hours in the great left extremity of the stomach : 3. that when it has undergone the process of digestion there, it is conveyed, with rather a sudden impulse, into the pyloric extremity of the stomach ; 4. that the chyme thus formed has undergone an animal process, becoming neither acid nor alkaline. Contemplating this illustration of the function of the stomach as a digesting organ, with the according action of its muscular fibres above described, a solid ground-work is afforded for the pathology of this organ.

Hunger and thirst.—We are solicited to take food by the uneasy sensation of hunger, and by the anticipation of the voluptuous sating of the appetite, and by the pleasures of the palate. Hunger is considered as the effect of the attrition of the sensible coats of the stomach upon each other by the peristaltic motion of the stomach and compression of the viscera. This is too mechanical an explanation. If the sensation proceeded merely from such attrition of the coats of the stomach, food received into the stomach would be more likely to aggravate than to assuage the gnawing of hunger : to excite the action of the stomach would be to excite the appetite ; and an irritable stomach would be attended with a voracious desire of food. Something more than mere emptiness is required to produce hunger. By some, hunger is supposed to proceed from the action of the gastric fluid on the coats of the stomach ; by others it is attributed to the dragging of the liver, now no longer supported by a full stomach. Hunger is like thirst, a *sense* placed as a guard calling for what is necessary to the system, and depending on the general state of the body. Morbid craving may proceed from many causes ; a tapeworm has occasioned bulimia, and spirits and high seasoning excite the appetite even when the stomach is full ; but natural hunger has reference to the state of the general system.

Thirst is a sensation seated in the tongue, fauces, œsophagus, and stomach. It depends on the state of the secretions which bedew these parts, and arises either from a deficiency of secretion, or from an unusually acrid state of it. It would appear to be placed as a monitor calling for the dilution of the fluids by drink, when they have been exhausted by the fatigue of the body and by perspiration, or when the contents of the stomach require to be made more fluid — the more easily to suffer the necessary changes of digestion.

The change on the secretion of the tongue and fauces from disorder of the stomach, is not, I imagine, a consequence of an influence communicated along the continuous surface. It has its origin in this natural constitution of the parts ; the connection which nature has established betwixt the stomach and tongue, betwixt the appetite and the necessities of the system. The state of the tongue, the loose or viscid secretions of the throat and fauces, even the secretion of the saliva, and the irritability of the larynx, are all influenced by the state of the stomach.

The more permanent and demonstrable effects on the tongue are principally attended to; which, perhaps, is the reason that we only know by this that the stomach is disordered, not how it is affected.

The cardiac orifice is the chief seat of all sensations of the stomach, both natural and unusual, as it is the most sensible part of the stomach. Indeed, we might presume this much by turning to the description and plates of the nerves; for we shall find that this upper part of the stomach is provided in a peculiar manner with nerves, the branches of the par vagum.

The sympathy of the stomach with the rest of the intestinal canal, the connection of the head and stomach in their affections, the effect of the disorder of the stomach on the action of the vascular system and of the skin, and the strict consent and dependence betwixt the stomach and diaphragm and lungs, and in a particular manner with the womb, testicle, &c. — and again, the connection of the stomach with the animal economy, as a whole, — must not escape the attention of the student of medicine.

OF THE INTESTINES.

That portion of the alimentary canal which extends from the lower orifice of the stomach to the anus is called the intestines. It is divided into the small intestines, and the great intestines; the small intestines are subdivided into the *duodenum*, *jejunum*, and *ileon*. The great intestines are subdivided into *cæcum*, *colon*, and *rectum*.

The marked difference of function is betwixt the small intestines and the great intestines. But betwixt the form and capacity of the stomach, the form and capacity of the small intestines, and the form and capacity of the great intestines, there is always a certain relation preserved in the different classes of animals.

The small intestines are estimated to be in length 26 feet, or from four to five times the length of the body, and the great intestines one length of the body, or about six feet. The younger the subject, the longer the intestinal canal. In an infant they were found to be upwards of eleven times the length of the body. In a child of one foot nine inches they were upwards of eight times the length of the body. In a child three feet one inch they were found to be seven times and one half the length of the body.*

Is this difference to be accounted for by supposing that a different food is applicable to the several ages, or is it an increase of absorbing surface accommodated to the necessities of the body while growing?

In the carnivorous animal the whole of the canal is shorter, being about five times the length of the animal: for example, in the lion. In the herbivorous animals the intestines are longer and more complicated, affording means for the retention or the delay of the descent of the food.

Of the small intestines, the first portion is that division extending from

* Sir Everard Home's Lectures.

the orifice of the stomach to the part where it is encompassed by the mesocolon. It is called the duodenum.

DESCRIPTION OF THE FIGURE.

A. The stomach. B B. The duodenum. C. The gall bladder. D. The pancreas and its duct. E. The ductus hepaticus. F. Ductus cysticus. G. The ductus communis coledochus, joined near where it pierces the gut by the pancreatic duct.

THE DUODENUM

Stands distinguished from the general tract of the small intestines by its shape, connections, and situation. It has been called duodenum, because it was usual to measure its extent by the breadth of twelve fingers. It is greatly larger than any other part of the small intestines; irregular and sacculated; more fleshy; and, although it has fewer plicæ, it is more glandular and more vascular: but its greatest peculiarity, and that which must convince us of its importance in the animal economy, and of the necessity of attending to it in disease, is this, that it is the part which receives the biliary and pancreatic ducts, and in which a kind of second stage of digestion takes place. This intestine takes a course across the spine from the orifice of the stomach. First it goes in a direction downward; then it passes upward till it touches the gall-bladder; then making a sudden turn it descends directly near to the right kidney, and it enters its *vagina*, or in other words, is involved in the mesocolon; and whilst so embraced, it takes a sweep towards the left side, obliquely across the spine, and a little downward. From this description it is obvious that it must be longer than the breadth of twelve fingers; and, indeed, I call duodenum all that portion of the intestine which is above the mesocolon, preferring a natural to an arbitrary boundary *; as in this

* Ruysch calls it "Intestinum digitale, vel intestinum rectum brevissimum." Adversar. Anat. ii.

See a good description of the duodenum by M. Laurent Bonazzoli, in the Transac-

extent, besides being tied down to the spine by the mesocolon, it has no mesentery, and the peritonæum is reflected off from it, covering it imperfectly. Of these reflections we have to remark the *ligamentum duodeno-renale*, and *ligamentum duodeno-hepaticum*, already described.

Although we shall presently treat of the coats of the small intestines in general, yet it may not be improper here to observe what are announced as peculiarities in the coats of this first division. The first or peritonæal coat is imperfect, as must already be understood: for it does not invest the whole circumference of the gut; it ties it down more closely, or it merely contains it in its duplicature, while a greater profusion of cellular membrane accompanies this than the other divisions of the intestines. The muscular coat is stronger than that of the jejunum and ileon; the plies formed by the inner coats smaller than those of the other part of the small intestine, and having more of a glandular structure. At the lower part of the first incurvation of the duodenum, the inner coat forms a particular process like to those which are called valvulæ conniventes; and in this will be discovered the opening of the biliary duct, within which also the ductus pancreaticus generally opens.

It is not without some reason that anatomists have considered the duodenum as a second stomach, calling it ventriculus secundus, and succenturiatus; for there is here performed a change upon the food, converting the chyme (as they have chosen to call it), which is formed in the stomach, into perfect CHYLE. But to suppose that the chyme is perfected in the duodenum, is to suppose the biliary and pancreatic secretions necessary to the formation of chyle; a point which is not allowed; for many suppose that the bile is merely a stimulus to the intestines, holding a control over their motions; others, that it is useful only in separating the chyle from the excrement; or again, that the bile is decomposed, part entering into the composition of the chyle, while the other goes into that of the fæces; it seems to bestow upon them a power of stimulating the intestinal canal in a greater degree; and, as the chyle is formed occasionally without the presence of bile, we may be induced the more readily to allow that the bile does not, in the natural actions and relations of the system, enter into the composition of the chyle. At all events, we see that it is the bile which is the peculiar stimulus of the intestinal canal, and that when interrupted in its discharge from the ducts, the motions of the belly are slow, and costiveness is the consequence.

There are poured into the duodenum, from the liver and pancreas, secretions which have an extensive effect on the system of the viscera; and we must acknowledge that the derangement of these secretions operates as a very frequent and powerful cause of uneasiness, and therefore that the duodenum must often be the seat of uneasy and distressing symptoms. We may observe that, from the course of the duodenum, pain in it should be felt under the seventh or eighth rib, passing deep, seeming to be in the seat of the gall-bladder, and stretching towards the right hypochondrium, and to the kidney, and again appearing as if on the loins. We may observe farther, that from the connections of this

tions of the Academy of Bologna. And the Dissert. L. Claussen. de duodeni situ et nexu. Sandifort, Thes. V. iii. Monro, Medical Essays.

portion of the intestine, and from the manner in which it is braced down by the mesocolon, spasm, when flatus is contained in it, will sometimes produce racking pains. Nay, farther, when the irregularities of digestion affect the duodenum, and spasm an indigestion follow ; the distention causes it to press upon the gall-bladder, and the pressure and excitement together cause an irregular and often an immoderate flow of bile, which, with the acrid state of the food, produces anxieties and increased pain, inverted motion, and vomiting.

We must not forget, that the inverted action of the stomach draws quickly after it the inverted motion of the duodenum. It may be of consequence to attend to this in the operation of an emetic, for the stomach will sometimes appear to be discharging foul and bilious matter, which we naturally may suppose to have been lodged in it, but which has actually flowed from the duodenum, or has even come recently from the ducts, in consequence of the operation of the vomit.*

From a defect in the natural degree of the stimulating power of the bile, it will accumulate in the duodenum, occasioning anxiety and loss of appetite, and even congestion of blood, and a jaundiced skin : we may certainly affirm that these, at least, are often connected. Such accumulation in the duodenum must be attended with a languid action of the whole canal, and inactivity of the abdominal viscera, because the peristaltic motion is begun here in the natural action of the intestines ; and if the proper stimulus be deficient here, so it will probably be in the whole system of the viscera. Hence the necessity of rousing the activity of the liver by evacuating the whole canal.

I may further observe, that it has been the opinion of the most respectable old physicians, those whose knowledge of diseases has been drawn from an acquaintance with anatomy, from the frequent inspection of dead bodies, and the observation of the symptoms during life, that the study of the diseases connected with the duodenum is the most important which can occupy the attention of the medical enquirer.†

OF THE JEJUNUM AND ILEON, OR INTESTINUM TENUE.

The small intestines, under the name of jejunum and ileon, occupy the space in the middle and lower part of the abdomen, the great mass forming convolutions in the umbilical region. The canal of the small intestines is gradually and imperceptibly diminished in diameter as it is removed from the lower orifice of the stomach ; so that the diameter of the gut at the termination of the ileon in the caput coli is considerably smaller than where it forms the duodenum. This tract of the small intestines performs the most important function of the chylopoietic viscera (if any can be said to be peculiarly important where the whole is so strictly connected) ; for here the food is moved slowly onward through a length of intestine four times that of the body, and exposed to a surface amazingly extended by the pendulous and loose duplicatures of the inner

* Indeed vomiting, in consequence of the concussion and compression it gives the whole contents of the abdomen, acting in a particular manner on the liver, affords most powerful means of operating upon the infarction and remora of the blood in the hepatic system.

† See Sandifort, vol. iii. p. 288. See Hoffman.

coat. Here the fæces are gradually separated from the chyle, and the chyle adhering to the villi is absorbed and carried into the system of vessels.

The JEJUNUM* is the upper portion of the small intestine. Its extent is two fifths of the whole. Its convolutions are formed in the umbilical region.

The ILEON.—The lower portion lies in the epigastric and iliac regions, and surrounds the jejunum on the sides and lower part, and forms three fifths of the whole extent of the intestine from the termination of the duodenum at the mesocolon to the beginning of the colon. The coats of the ileon are thinner and paler and more transparent than those of the jejunum, and the diameter of the gut is less; the valvular projections of the inner coat are less conspicuous, so that there is less of a fleshy feeling communicated to the touch; and the mucous glands become more apparent in the lower portion than in the upper portion of the small intestine.

There is sometimes found a lusus in the lower part of the ileon before it passes into the colon: a blind pouch *diverticulum*, or *cæcum*, is attached to the ileon, resembling the caput coli. I have found many instances of this, and several specimens may be seen in my Collection. Sometimes there is more is more than one diverticulum in the course of the ileon.†

THE PERITONÆAL COAT AND MESENTERY.

The peritonæal coat of the small intestines is of the same nature with that of the stomach. It is thin, smooth, and possessing a certain degree of elasticity. On the surface it has a moisture exuding from its pores; and it firmly adheres to the muscular fibres beneath by a very dense cellular substance. Its transparency makes the muscular fibres, blood-vessels, and lymphatics easily distinguishable; and, when it is dissected or torn up, the longitudinal muscular fibres will be found in general attached to it. Its use is to give a smooth surface, and to strengthen the intestines, and in a great measure to limit the degree of their distention.

The peritonæal coat of the intestine is continued and reflected off upon the vessels and nerves which take their course to the intestine; or, what is the same thing, and indeed is the more common description, the two laminæ of the peritonæum which form the mesentery, after proceeding from the spine and including the vessels, nerves, and glands belonging to the tract of the intestine, invest the cylinder of the intestine under the name of peritonæal coat.‡

The MESENTERY is composed of membranes, glands, fat, and the several systems of vessels, arteries, veins, lacteals, and nerves. As in reality it is a production of the peritonæum, it may be said to arise from the mesocolon, or the mesocolon from the mesentery, reciprocally. But

* So named from its being more generally empty.

† These appendices cæcales of the ileon have given birth to a curious question in the pathology of hernia. See "Hernia ab ilii diverticulo." Morgagni, Adv. Anat. iii. "Hernie formée par l'appendice de l'ileon." LITTRE, Mém. del 'Acad. Royale des Sciences, an 1700: Ruysch, Palfin, &c. See cases of anus at the groin in the Museum.

‡ See the Plan of the Peritonæum.

at present we may trace the mesentery from the root of the mesocolon —for the jejunum, emerging from under the embrace of the mesocolon, carries forward the peritonæum with it; and the laminæ of the peritonæum, meeting behind the gut, include the vessels which pass to it and form the mesentery. This connection of the small intestines by means of the prolongation of the peritonæum, while it allows a very considerable motion, preserves the convolutions in their relations, and prevents them from being twisted or involved. But it is by the walls of the abdomen that the intestines, as well as the more solid viscera, are supported; for when the bowels escape by a wound, a portion of an intestine will hang down upon the thigh, unrestrained by the connection with the mesentery.

The mesentery begins at the last turn of the duodenum, or beginning of the jejunum. It roots runs obliquely from left to right across the spine. Here it has, consequently, no great extent; but, as it stretches toward the intestines, it spreads like a fan, so that its utmost margin is of very great extent, being attached to a portion of the canal, which we have estimated at four times the length of the body. In the middle of the small intestine the mesentery has its greatest extent or breadth; towards the beginning of the duodenum and the termination of the ileon it is shorter, and more closely binds down the intestine.

MUSCULAR COAT OF THE INTESTINES.

The peritonæum is united to the muscular coat by a very delicate and dense cellular membrane; which in the enumeration of the coats we must call the first cellular coat, but which really does not deserve the name of a distinct coat; for, as already said, the outer lamina of the muscular coat is raised with the peritonæum, and adheres intimately to it. The fibres of the muscular coat of the intestines are simpler than those of the stomach; for here there are only two sets of fibres the longitudinal and circular fibres. The outer stratum consists of the very minute and delicate longitudinal fibres. Indeed, when the system has been exhausted by a long and debilitating illness, with scarcely any excitement of the intestinal canal, these fibres are not to be observed. In a man who has been cut suddenly off by disease, or who has died a violent death, they are more demonstrable; and in diseases where there has been congestion and excited action in the intestines, they become, of course, still stronger and more discernible. The internal stratum of the muscular fibres is much stronger and more easily demonstrated. These fibres will be observed much stronger about the duodenum and upper part of the jejunum; but they become weaker and more pellucid towards the extremity of the ileon. Tracing any particular fibre of the circular stratum, it is found to form only a segment of a circle, a part of the circuit of the intestine. It seems lost amongst neighbouring fibres or cellular connections; but still, taken together, the circular muscular fibres uniformly surround the whole gut.*

To account for that action of the intestines which urges on the food, we may suppose a greater degree of irritability and activity to reside in

* Morgagni Adversaria Anatomica iii. Animadversio v.

the upper portion; where, of course, is commenced that action which is successively propagated downwards, carrying the fæces into the lower part of the canal. Some anatomists have ingeniously imagined that the inner stratum of fibres surrounds the intestine, not in a circular direction, as was asserted by Willis, but obliquely and in a spiral course; from which followed a simple explanation of their effect, since the contraction of the fibre winding lower in the intestine pursued the contents with a uniform, progressive constriction.

Physiologists have made a distinction in the motion which they have observed in the intestines of living animals: the one they call the vermicular, and the other the peristaltic, motion. Upon looking into the belly of a living animal, or of one newly killed, there may be observed a motion among the intestines—a drawing in of one part, and a distention and elongation of another part of the convolution. This motion has some resemblance to the creeping and undulating motion of a reptile, and has got the name of vermicular motion. On the other hand, the direct contraction of the gut by the constriction of the circular fibres is the peristaltic motion. We must not, however, allow ourselves, from the loose expressions of authors, to imagine, that these circular and straight fibres act separately: on the contrary, excited by the same stimulus, they have a simultaneous motion to the effect of accomplishing the perfect contraction of the gut and propulsion of its contents.*

While the stimulus is natural, the contractions of the muscular coat are in a regular succession from above downward, and, the lower part contracting before the upper is completely relaxed, the food must be urged downwards into the lower portion: the lower portion becomes relaxed at the same time that the upper portion is contracted.†

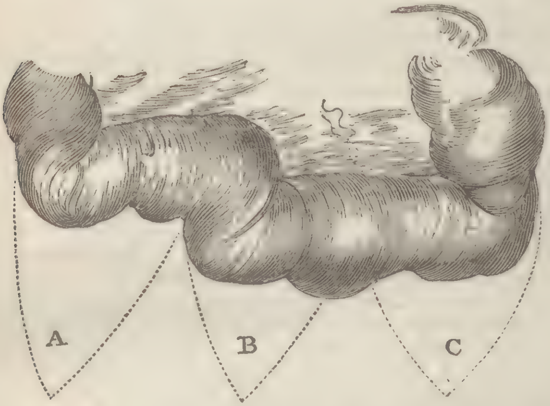
ANTIPERISTALTIC MOTION.

When the successive contraction of the muscular fibres of the intestines is opposed in its natural course downward, either by a violent stimulus (the effect of which is to cause a more permanent contraction in the coats, and one which does not readily yield to the relaxation that follows, as in the natural contraction), or when there is a mechanical and obstinate interruption to the contents of the bowels, then is the natural action reversed. This antiperistaltic motion arises thus: a portion of the intestine being constricted, and not yielding to the contraction which, in the natural action of the gut, should follow in order, the gut must be stationary for a time, until the part above that which is contracted becomes relaxed; then the contents of the intestine finding a free passage

* Neither can I allow that the acting of the longitudinal fibres in one portion of an intestine dilates that which is below, otherwise than through the compression of food and flatus.

† From the experiments of Haller and others, it is proved that the irritability of the intestines long survives that of the heart: that the intestines are in general in lively motion, when no motion can be observed in the stomach; but that sometimes the motion of the stomach continues longer than that of the intestines. It is proved, also, that the action of the intestine is adequate to the motion downward and the discharge of fæces, without the aid of the abdominal muscles. See *Mém. par Haller sur les Mouvemens des Intestines;* and *Opera Minora*, p. 393.

upwards, and that portion contracting and propelling the matter still upwards and retrograde (since it is opposed by the contraction below), a series of retrograde or antiperistaltic motions are begun and propagated. The course of the action being changed, the contraction of the gut is not followed by the dilatation of the portion below, but by that above. By this means the matter of the lower portion of the intestinal canal is carried into the upper part, and there acting as an unusual stimulus, it aggravates and perpetuates the unnatural action. From experiments it appears, that a permanent irritation will cause an accelerated motion in both directions; that from the point stimulated there will proceed downward the regular series of contractions, and dilatations, while the motion is sent upwards and retrograde from the same point of the intestine towards the stomach.* And this observation the exhibition of medicine and the diseases of the intestines confirm. But, farther, we may observe, that the food is not uniformly moved downwards: it is shifted and agitated by an occasional retrograde motion, thus:—



The portion of the intestine included under A contracts and sends its contents into B. B, contracting, sends its fluid contents in part backward into A, but in a greater proportion into C. While the contents of the middle portion are sent into the lower part in a greater proportion than into the higher division, the tendency of the food will be in its natural course, downward; whilst at the same time it suffers an alternate motion backward and forward; so that it is more extensively applied to the absorbing surface of the intestines.

The stimulus to the intestines is matter applied to their inner coat; and although there is much sympathy in the whole canal, yet, unless there be matter within a portion of the canal, that particular part has little action. Accordingly, when there is obstruction to the course of the aliment, by whatever cause it may be produced, the portion below becomes shrunk and pale, and free from the effects of inflammation; while

* Haller, loc. cit., Exper. 424.

the part above stimulated by the food, being in a high state of excitement, irritated by the presence of matter which it is unable to send forward, evacuated only partially by an unnatural and highly-excited retrograde action, becomes large, thick in its coats, strong in its muscular fibres, and greatly inflamed, till it terminate at last in gangrene.*

The unusual excitement of the muscular fibres produces a very curious effect in the intus-susceptio, which is the slipping of one portion of the gut within another. This may be produced by applying acrid matter to the intestines of living animals; and I have no doubt that it has been produced by giving purges too strong and stimulating in cases of obstruction of the bowels. By the contractions of the muscular coat greatly excited, the intestine is not only diminished in diameter, so as to resemble an earth-worm†, but in length also. This great contraction of the outer coats accumulates the vascular and villous coat as if into a heap, which from the compression of the muscular coat is forced into the neighbouring relaxed portion. This first step leads only to a succession of actions; for the fibres of the relaxed or uncontracted part, sensible to the presence of this accumulated and turgid villous coat, contract in succession so as to draw a part of the contracted gut further downwards. If the irritation is done away or ceases quickly, as in the experiments on animals, another turn of the intestine coming into play distends this, and undoes the intus-susceptio. But if the cause continues, the intus-susceptio is continued; the included part of the gut is farther forced into the other. By these means the vessels going to the included part are interrupted; the villous coat swells more and more; and several feet of the upper portion of the intestine are often in this way swallowed down. It is not, however, in the natural course downward that this preternatural action always proceeds; for as the excitement is violent and unlike the usual stimulus of food, and as we know that an unusual excitement is very apt to cause an inverted action, it often happens that the intus-susceptio is formed by the lower portion of the gut being included in the part above.‡

* Haguenot gives an experiment illustrating the cause of ileus. He tied a ligature about the intestine of a cat, and found no antiperistaltic motion excited. This is not wonderful: it is the excitement arising from matter within the gut, to which there is no exit, and not the stricture of it, which is the cause of the violent symptoms. Many cases in the Museum will give the young student a correct judgment on this subject.

Vide Scholium sub tit. Calculus insignis Ilii. Observ. F. Biumi. Sandif. Thes. vol. iii.

The figure represents the *intus-susceptio*. A the part above the invaginated portion; B the including portion.

† See Haller's Experiments, *Opera Minora*, and "Dissections of the Atrophia Ablactatorum," with plates, by Dr. Cheyne. Sandifort, vol. ii. p. 381. in Dysentariæ.—Ibid. 244.

‡ See a case, in which a portion of intestine 18 inches in length, with its connecting

VASCULAR COAT.

The third coat of the intestines is a stratum of cellular membrane in which the vessels of the gut are distributed. It might with equal propriety be called the cellular coat; and is, indeed, what some anatomists have called the third cellular coat. By inverting the gut and blowing strongly into it, the peritonæal coat cracks and allows the air to escape into this coat; which then swells out, demonstrating its structure to be completely cellular.* Its use evidently is to suffer the arteries, veins, and lymphatics to be distributed to such a degree of minuteness as to prepare them for reflection into the last and innermost coat, and for entering into the structure of the villi: for they come to the extremity of the mesentery as considerable branches, but forming in this coat many ramifications, and these subdividing, their extreme branches are finally distributed to the inner coat. This is the coat in which, in some parts of the intestines, little glands or cryptæ are lodged.

VILLOUS COAT.

The most curious part of the structure of the intestines is the villous or inner coat; for by its influence is the chyle separated from the general mass of matter in the bowels, and carried into the system of vessels. To this all we have been describing is merely subservient.

The villous coat has a soft fleecy surface; and, being of greater extent than the other and exterior coats, it is thrown into circular plaits or folds which hang into the intestine, and take a valvular form. They have the name of VALVULÆ CONNIVENTES. Some of them go quite round the inside of the intestine; others only in part. They are of larger or smaller extent in different parts of the canal: for example, they begin a very little way from the lower orifice of the stomach irregularly, and tending to the longitudinal direction; further down they become broader, more numerous, and nearly parallel: they are of greater length, and more frequent in the lower part of the duodenum and upper part of the jejunum. These valvular projections have their edges quite loose and floating in the canal; and from this it is evident that they can have no valvular action. Their use is to increase the surface exposed to the aliment; to enlarge the absorbing surface; and at the same time to give to it such an irregularity that the chyle may lodge in it and be detained. Into the structure of these plicæ of the villous coat, the vascular or cellular coat enters, and generally in the duplicature a small arterial and venous trunk will be observed to run. That these plicæ are formed chiefly by the laxity of the connection and the greater relative extent of the inner coat, is apparent upon inverting the gut, and insinuating a blow-pipe under the villous coat, for then you may distend

mesentery, was discharged by stool; and the dissection, in Duncan's Medical Commentaries, vol. ix. p. 278.

* An experiment to which Albinus attaches much importance. See also, in the Acad. de Bologna, a paper by Mr. D. G. Galeati on the fleshy coat of the stomach and intestines.

the cellular substance of the vascular coat so as entirely to do away the valvulæ conniventes.

The pile or lanuginous surface, from which this coat has its name, is to be seen only by a very narrow inspection, or with the magnifying-glass. It is owing to innumerable small filaments, which project from the surface like hairs at first view, but of a flat or rounded figure as they are exhibited in a state of fulness and excitement or depletion. They consist, (as appears by the microscope) of an artery and vein, and lacteal or absorbing vessels, and to these we may surely add the extremity of the nerve. They have a cellular structure; they are exquisitely sensible: and, when stimulated by the presence of fluids in the intestines, are erected and absorb the chyle. They are the extremities of the lacteal absorbing system, and their structure is subservient to the absorption by the mouth of the lacteal vessel.*

But the surface of this coat is not only an absorbing one, it also pours out a secretion; and, indeed, as a secreting surface, upon which medicines can act, it is to us one of the most powerful means of correcting the disordered state of the system. The fluid which is supplied by the surface of the intestines is called the liquor intericus—a watery and semipellucid fluid, resembling the gastric fluid. This fluid physiologists have affected to distinguish from the mucous secretion of the glands of the inner surface of the intestines; but it is impossible to procure them separate.†

GLANDS.

Anatomists have observed small mucous glands seated in the cellular membrane of the intestines‡, the ducts of which they describe as opening on the villous surface of the intestines. They are seen as little opaque spots when the intestine is cut in its length and held betwixt the eye and the light. They have been chiefly observed in the duodenum; few of them in the general tract of the small intestines. Little connections or agmina of glands are observed, which increase in frequency toward the extremity of the ileon. It is natural to suppose, that, as the contents of the intestines become in their descent more acrid and stimulating, there will be a more copious secretion of mucus in the lower intestines for the defence of the villous coat. According as these bodies are found single or in collections, they have been called glandulæ

* See further of their structure under the title of the LACTEAL and LYMPHATIC SYSTEM, where the subject of absorption and the structure of the villi is treated. Dr. Hunter and Mr. Cruikshanks observed about fifteen or twenty orifices in each villus. These communicated with radiated branches of absorbents, which together formed the trunk of one of the lacteal vessels.

† It has been supposed that the fluids excreted from the surface of the intestines were furnished by very minute foramina (which are visible by particular preparation) in the interstices of the villi. See the letter of Malpighi to the Royal Society of London, on the pores of the stomach; and the paper by M. Galeati, in the Bologna Transactions, on the Inner Coat, which he calls the Cribriform Coat. These pores, according to Galeati, are visible through the whole tract of the canal, and particularly in the great intestines.

‡ Peyerus Biblio. Manget. Brunnerus de Glandulis Duodeni. Morgagni Adversar. An. iii. viii. These he supposed additional pancreatic glands.

solitariæ or agminatæ. Sometimes they are called glandulæ Peyeri or Brunneri.

FUNCTION OF THE SMALL INTESTINES.

In concluding the view of the small intestines, we cannot fail, I think, to express a correct idea of their function: the matter ejected from the stomach is a greyish, pultaceous, turbid mass. In the small intestines we find that a precipitation or separation of feculent matter has taken place from the nutritious part.

This nutritious matter, called chyle, is a pure milky fluid, and coagulable; so that already the most remarkable character of the circulating blood is assumed by the digested matter. And, what is still more curious, already do we see that consent established betwixt the containing and the contained fluids which is the source of all the actions of a living body. The chylous or nutritious matter from which the feculency is separated is attracted by the surface of the villous coat of the intestine, and in an animal killed some time after taking food, the matter may be seen coagulated upon the inner surface of the intestine.

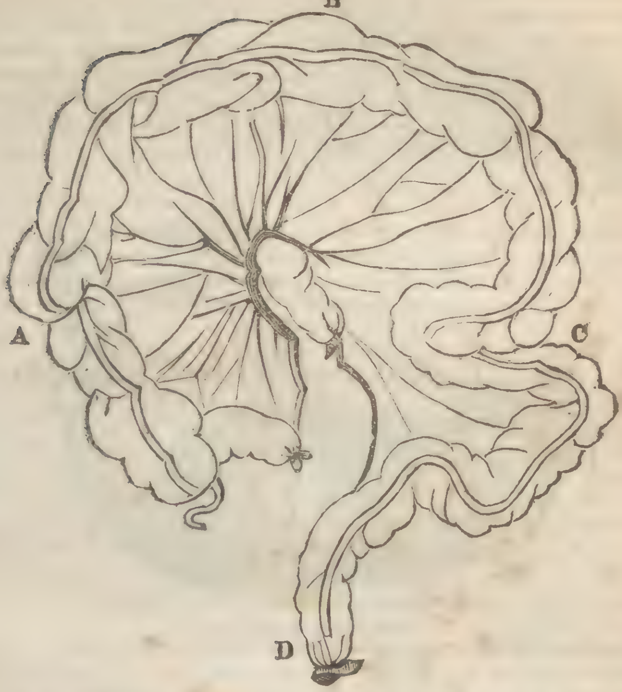
Some are of opinion that the *chylification* is produced by the action of the bile, and that the effect of it is to precipitate the effete matter; but I am more inclined to believe that it is the office of the part of the intestines we are now considering to separate, by attraction, the chyle from the mass of ingesta: for supposing that we were to give the office to the bile, that would be a mere precipitation, and could not explain the attraction of the chyle to the villi*, nor the manner in which the fine nutritious fluid was imbibed by the lacteals, while the feculent part is passed down. There is a preparation of the alimentary matter; but is not the absorption by the lacteals like the action of the roots of plants? They must exercise a selection, and possess a power of separating; nor is it more wonderful that the orifices of vessels should affect the morbid fluid, than that they should retain the power we so readily acknowledge them to possess, of separating and changing the blood in the act of secretion.

It is more natural to suppose, that this very peculiar property of life, the coagulation, is bestowed through the influence of the villous surface of the intestine, than produced by the mere pouring in of a secretion like the bile.

OF THE GREAT INTESTINES.

The great intestines form that part of the intestinal canal which is betwixt the extremity of the ileon and the anus. They differ essentially from the small intestines in their size, form, and general character; and in the texture, or at least in the thickness, of their coats.

* In Sir A Cooper's lectures in the College of Surgeons, this attachment of the chyle to the villi was considered as a discovery; but the statement will be found in former editions of this work.



The great intestine, beginning on the right side of the belly, rises before the kidney; passes across the upper part of the belly under the liver, and before or under the stomach.* Then, making a sudden angle from under the stomach and spleen†, it descends into the left iliac region. Here, making a remarkable turn and convolution, it descends into the pelvis by a curve running in the hollow of the sacrum.‡

The great intestines are accounted to bear a relation to the small intestines as five to twenty-five.

The natural division of this portion of the intestine is into the *cæcum*, *colon*, and *rectum*.§

VALVULA COLI.||

The extremity of the intestinum ileon enters, as it were, into the side

* This turn of the colon from the right across the belly is flexura prima, superior dextra hepatica. Soemmerring.

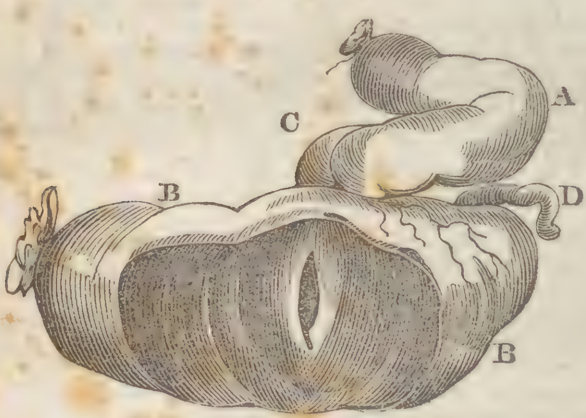
† Flexura secunda, superior sinistra linealis.

‡ Description of the figure. A the ascending colon; B the transverse arch; C the sigmoid flexure; D the rectum.

§ Some authors divide the great intestine into six parts, enumerating the cæcum, pars vermiformis, the right, the left, and the transverse colon, and the last part or rectum.

|| *Valvula Coli*, or *Valvula Bauhini*, or *Valvula Tulpii*.

of the great intestine at an angle.* And here there is a valvular apparatus formed by the inner membrane of the gut, which, more than any other circumstance, marks the distinction betwixt the small and great intestines; for, as the effect of this valve is to prevent the regurgitation of the fæces into the small intestines, it marks sufficiently the nature of the change produced on the ingesta in their passage through the small intestine, and how unfit, in their changed and acrid state, they are to be longer allowed lodgement in the small intestines.



DESCRIPTION OF THE FIGURE.

The figure represents the caput coli, dried and cut open.

A The ileon.
B The colon.
C The valve of the colon.
D The appendix vermiformis.

Upon opening the caput coli, or lower part of the colon, on the right side, and examining the opening of the ileon into it, we see a slit formed betwixt two soft tumid plicæ of the inner membrane of the gut: the one of these is superior; the other inferior. They are soft and moveable, and seem scarcely calculated for a valvular action. But there is little doubt that when the great gut is distended or in action, they are calculated to resist the retrograde passage of the fæces into the ileon, though not absolutely to prevent it, as we know from what is vomited in the iliac passion.† In the form of the opening of the ileon, and in the broadness of the valvular membranes, there is considerable variety. The superior valve is transverse, smaller and narrower than the lower one; the lower one is longer, and takes a more extensive curve; and sometimes the lower one is so remarkably larger than the upper valve, that it gives a degree of obliquity to the insertion of the ileon into the colon, so as to approach to that structure which we see in the entrance of the biliary duct into the intestine,

* Of the opening of the small intestine into the greater, see Morgagni Adversar. iii. Animad. xi.

† Morg. Advers. A. iii. An. ix. Kerckrinigus Observ. xxxi.

or the ureter into the bladder. At their extremities these valves coalesce and run into the common transverse folds of the colon : and this is what Morgagni has called the fræna or retinacula.* At this place of union of the ileon and colon the longitudinal muscular fibres of the ileon are mingled and confounded with the circular fibres of the colon.† The circular muscular fibres certainly enter so far into the composition of the valve, that they embrace the margin, and, by contracting during life, must make the experiments on the action of this valve in the dead body less decisive than they would be, were we certain that this valve acts on principles strictly mechanical.

The discovery of the valve of the colon, which, from its action in guarding the ileon, might rather be called the valve of the ileon, has been attributed to many anatomists, chiefly to Varolius, Bauhin, and Tulpius ; and it sometimes receives the name of the two latter anatomists.

CŒCUM.

We have seen that the ileon is inserted into the side of the colon : now that portion of the gut which is below this union of the ileon is a round or slightly conical sac, from two to three inches in length. It is attached by cellular membrane to the iliacus internus muscle. It is not a regular sac, but is divided into large cells like those in the rest of the colon, and has some variety of form in different subjects.

PROCESSUS, SEU APPENDIX, VERMIFORMIS.

There is appended to the cœcum a small gut, also blind ; but bearing no relation in size or in figure to any part of the intestinal canal. This gut, from its smallness and twisted appearance, like a writhing earthworm, has received the name of vermiformis. It is somewhat wider at the connection with the great intestine, and stands off obliquely, so that sometimes its inner membrane takes the form of a valve.‡ It scarcely ever is found containing fæces, but only a mucus excreted from its glands. In the fœtus the appendix vermiformis is comparatively much larger, its base wider ; upon the whole, more conical, and containing meconium ; and in the young child it often contains fæces. The cœcum and appendix in the human subject are just sufficient, like the form of the teeth, the stomach, and the intestines, generally to show that man holds an intermediate condition among graminivorous and carnivorous animals. The cœcum is one of the many means of retarding the descent of the food through the colon ; and it is found long and intricate in such animals as have a colon otherwise calculated to retain their contents. In carnivorous quadrupeds and birds the cœca are short ; and in the graminivorous quadrupeds and birds the cœca are long.

GREAT DIVISIONS OF THE COLON.

The great division of the colon are these : First, the RIGHT DIVISION

* Animad. xiii. † Winslow.
‡ Morgagni. M. Laur. Bonazzoli in the Acad. of Bologna.

of the COLON rises from the insertion of the ileon, and from that part of the great intestine which is tied down by the peritonæum and cellular membrane, and ascends on the right side of the small intestines, until it gets under the margin of the liver, and in contact with the gall-bladder. This part will be found to have some considerable variety in its form, as it is more or less distended. (It is marked A in the figure.)

THE TRANSVERSE COLON.*

The transverse colon is that part of the great intestine which takes a course across the belly, and which generally forms an arch before or immediately under the stomach. (It is marked B.) When this part of the colon, however, is much distended, being at the same time held down by the mesocolon, its angular turns reach under the umbilicus, nay, even to the pelvis.†

The LEFT OF DESCENDING COLON is short: for from the place where the colon begins to bend down on the left side, to those violent turns which it takes before terminating in the rectum, it is but of small extent. Here it is attached to the diaphragm and psoas muscle.

The SIGMOID FLEXURE‡ of the colon C, is formed by a narrowing and contraction, and closer adhesion of the gut to the loins below the left kidney, and to the cup of the ilium, by the peritonæum, which has the effect of throwing it into some sudden convolutions. The colon then terminates in the rectum D.

PECULIARITIES IN THE COLON DISTINGUISHING IT FROM THE SMALL INTESTINES.

The coats of the great intestines are the same in number and in structure with those of the small intestines; but they are thinner and more difficult to be separated by dissection. The villi of the inner coat are smaller; indeed betwixt the villous coats of the ileon and the cœcum there is a distinction abruptly marked§; the mucous glands or follicles are sometimes very distinct; and, lastly, the muscular fibres have some peculiarities in their arrangement. The most characteristic distinction in the general appearance of the great and small intestines is the notched and cellular appearance of the former. The cells of the colon being formed betwixt the ligamentous-like stripes which run in the length of the gut, have a regular threefold order. These cells give lodgment to the fæces; retain the matter; and prevent its rapid descent or motion to the rectum. Here the fluids are still more exhausted, and the fæces take often the form of these cells. When the great intestines are torpid, and inert in their motions, the fæces remain too long in the cells of the colon, and become hard balls or scybala. But when in this state of costiveness, the intestines are excited by medicine, not only is the peristaltic motion of

* COLON TRANSVERSUM. ZONA COLI.

† For the varieties in the situation of this intestine and the viscera in general, see Morgagni Adversar. Anat. ii. Animadver. ii.

‡ From its resembling the Roman S.

§ Vide Albin. Annot. Acad. l. vi. c. viii. de intestinis, et tab. ii. f. vii.

the intestines increased, but the vessels pour out their secretions, loosening and dissolving the scybala.*

MUSCULAR COAT.

The ligamentous-like bands of the colon form three fasciculi running in the length of the gut: one of these, obscured by the adhesion of the omentum, is not seen without dissection; and the other is concealed by the mesocolon.† These bands are formed by the longitudinal fibres of the gut, being concentrated into fasciculi, and not uniformly spread over the general surface, as in the small intestines; and being at the same time more firmly connected with the peritonæal coat, they give the appearance outwardly of ligament more than of muscular fibres.‡ The inner or circular muscular fibres of the great intestines are like those of the small intestines, uniformly spread over their surface, and are stronger than those of the latter.

RECTUM.

The RECTUM§ forms the last division of the great intestines; and I know no better proof of the impracticability of altering the names in anatomy than this, that anatomists have, in almost every age, insisted on the impropriety of calling this gut, which answers in its shape to the curve of the sacrum, a straight gut; and yet always, even to the present day, it is rectum.

From the last turns of the colon, called sigmoid, the gut is continued over the promontory of the last vertebra and sacrum (a little to the left side), and falls into the pelvis. It runs down, in a curved direction, betwixt the sacrum and bladder of urine. In the upper part it is covered by the peritonæum, and has its fatty appendages like the colon, but less regular; and sometimes the fat merely deposited under the peritonæal coat. It is tied down by the peritonæum, in form of mesorectum; but, deeper in the pelvis, it loses the peritonæum, (which, as we have said, is reflected up upon the back of the bladder, and forms here lateral folds,) and the rectum is connected with the lower part of the bladder and vesiculæ seminales by cellular membrane. In women, the muscular fibres of the rectum and vagina are intimately connected.||

The muscular coat of the rectum is particularly strong. The fleshy bands of the colon, spreading out, are continued down upon the rectum in an uniform sheath of external longitudinal fibres. The circular fibres of this part of the gut are also particularly strong; and towards the extremity, appearing in still stronger fasciculi, they obtain the name of sphincter, of which three are enumerated; and this, to distinguish it from the others, is called the intestinal or orbicular sphincter.

* See note of the pores of the intestines.

† Stratum liberum, stratum omentale, et tertium mesocolicum.

‡ See Morgagni. See also Galeati on the fleshy coat of the stomach and intestines, in the Memoirs of the Acad. of Bologna.

§ The name *rectum* is taken from the old anatomists, who described from brutes. A professor of Edinburgh calls it *curvum*, but this I cannot admit after reading Morgagni Epist. Anat. xiv.

|| Winslow.

The internal coat of the rectum does not deserve the name of villous, nor of papillaris. Its surface is smooth, and there are often distinctly seen little foramina like the mouths of ducts or follicles, in part the source of the mucous discharge, which is sometimes poured out from this gut. Towards the anus the folds become longitudinal, and terminate in the notched-like irregularities of the margin.*

FUNCTION OF THE GREAT INTESTINES.

One obvious use of the great intestines is to be a receptacle for the useless part of the food, that the matter descending through the small intestine may not be voided as it descends. In the next place we see, that, in proportion as the quantity of the ingesta is great to the really nutritious part, the great intestines are capacious and long. Thus in the goat, the great intestines are twenty feet nine inches in length, while in the lion they are three feet eight inches;† which is an increase of length of intestine in the herbivorous animal more than in the carnivorous, by as much as the quantity of the useless part of the vegetable food is great in proportion to the animal food.

Mr. Cooper, in his lectures to the College of Surgeons, gave the most diverting reason for the colon of sheep, and some other animals, being of a form calculated to retain the fæces, and form them into round dry pellets. The fact is, that it is in the colon that the water is absorbed, for the necessities of the system. These animals, inhabiting lofty, dry, and sandy places, or extensive plains, have this structure of the great intestines to enable them to extract the whole moisture from the food, and, consequently, the less frequently to require drink.

Professor Coleman has observed, that the water drank by a horse is very quickly conveyed through the canal, and deposited in the great intestines.

It is matter of daily proof, that the aliment is deposited in the right colon liquid; that in arriving in the rectum it is deprived of fluid; and that the lymphatics of the great intestine are found distended with a limpid fluid. From such views I have entertained the opinion, that a very principal office of the great intestines was to imbibe the fluid from their contents in proportion to the wants of the system.

But there is another office obviously performed by the intestinal canal,—secretion, or rather excretion. The surface of the intestine is the organ by which that matter (the waste incident to the changes of the economy,) which is not carried away in the urine, is thrown out of the system.

The fæces contained in the great intestines, though offensive, are not putrid; and the rapid change which takes place in the matter by chymical combination, when voided, implies that there is a controlling influence of the great intestine over its contents. Hence we may believe, that, in derangement of function of the bowels, this controlling influence

* The presence of stricture within the anus seems to have given rise to the idea of there being a valve here. Morgagni Adversar. An. iii. Animad. vi.

† Sir Everard Home's Lectures.

being lost, such chymical change or putrefaction may take place in the contents of the colon, as to render them a new source of morbid irritation.

Not being satisfied with the observations I have met with on the different gases found in the intestinal canal, I may be excused omitting to notice them in a book of anatomy.

OF THE SOLID OR GLANDULAR VISCERA OF THE ABDOMEN.

The solid or glandular viscera of the abdomen are the liver, the spleen, the pancreas, the kidneys, the glandulæ capsulares.

OF THE LIVER.

Our attention is first drawn to the liver, as it holds in so eminent a degree the sovereignty over the motions of the intestinal canal, and as it is so strictly connected with it by its system of vessels, and by its functions. The liver is the largest viscus in the body; and as in its size and proportion to the whole body it is great, so are its connections in other respects with the whole system very intimate. This is particularly evident in the diseases of the liver, and was the cause of the ancients ascribing to it so eminent a place in the economy.

In all ages authors have paid particular attention to the liver, and have exercised their ingenuity in giving various explanations of its function. The ancients made it the supreme director of the animal system. They supposed that they could trace the nutritious fluids of the intestines through the meseraic veins into the porta and into the liver, and that it was there concocted into blood. From the liver to the right side of the heart they found the cava hepatica carrying this blood, as they supposed, already formed in the liver, to the centre of the system in the heart; and through the veins they supposed the blood to be carried to the remote parts of the body. All this, it is well known to my reader, is error.

Seat of the liver.—The liver is seated in the upper part of the abdomen, under the ribs, and towards the right side, or principally in the right hypochondrium. In the fœtus it occupies more of the left side than it does in the adult. Indeed it is nearly equally balanced in the fœtus, but the older the animal (at least during the first five years) the greater will be the proportion of it found in the right side.

Without going into the more minute subdivisions of this viscus, we may observe, that it is more uniform and smooth, and convex on the upper surface; on the lower, more irregularly concave. Its upper surface is applied in close contact to the concavity of the diaphragm, and in the fœtus its margin is in contact with the abdominal muscles, because it falls lower than the margin of the ribs. Its lower and concave surface receives the convexity of the stomach, duodenum, and colon. In a healthy adult subject, the liver does not extend from under the margin

of the ribs, unless near the pit of the stomach, but in the fœtus and child it is much otherwise. In a fœtus of the third and fourth month the liver almost fills the belly: it reaches to the navel, covers the stomach, and is in contact with the spleen. After the seventh month other parts grow with a greater rapidity in proportion. Indeed some have affirmed, that the liver, or at least the left lobe, actually decreases towards the time of birth.* But from this time to the advance to manhood the chest becomes deeper; the sternum is prolonged, and the diaphragm becomes more concave; so that the liver retires under the margin of the ribs, and its edge on the left side in the adult reaches no farther than to the œsophagus. When the liver becomes scirrhous and enlarged, its hard margin comes down so as to be felt through the abdominal parietes under the border of the chest. This enlargement of the liver, and consequent descent of its margin, is to be felt more easily by grasping the integuments of the belly, as if you expected to lift up the acute edge of the liver, than by pressing with the point of the finger. By this means we shall be sensible of the elasticity and softness proceeding from the intestines, below the liver, and of the resistance and firmness of the margin of it. The physician, however, should not forget, that the depression of the diaphragm, and consequent protrusion of the liver by disease in the thorax, gives the feeling of an enlargement and hardening of the liver. The left great division of the liver is perhaps as often diseased and enlarged as the right, in which case, it is more difficult to ascertain it by examination.

Neither should a physician be ignorant, that by suppuration in the lungs, and consequent rising of the diaphragm, the liver is elevated considerably, so as to retire farther under the protection of the false ribs. It is a most common error in practice, for the physician to mistake the square contracted portion of the right rectus for the enlarged liver.

M. Portal, by running stilettos into the belly of the subject as it lay upon the table, or was raised into the perpendicular posture, found that in the latter posture the liver shifted two inches. But it is almost superfluous to remark concerning these experiments, that they are by no means conclusive. In the dead body, the abdominal muscles are relaxed: they yield to the weight of the viscera; and the diaphragm is pulled down by the weight of the viscera. The margin of the liver necessarily falls lower, but in the living body there is a close and perfect bracing of every part by the abdominal muscles: they do not yield, and very little if any alteration can take place in the situation of the viscera.

It must be observed, however, that a considerable motion of the liver is a consequence of respiration, and of the action of the diaphragm. This motion is chiefly on the back part of the right lobe of the liver. The left lobe being more on the centre of the belly, and, consequently, opposite to the centre and less movable part of the diaphragm, it is less affected by the respiration than the larger right lobe.

LIGAMENTS OF THE LIVER.

The peritonæum is reflected in such a manner from the neighbouring parts upon the liver as to form membranes receiving the name of liga-

* M. Portal Acad. des Sciences, 1773.

ments. It has been explained, however, that these are not the sole support of this viscus; and that the compression of the surrounding abdominal muscles is the principal support of the liver, as it is of the other viscera.

The BROAD LIGAMENT* of the liver is formed by two laminæ of the peritonæum, connected by their cellular membrane, descending from the middle of the diaphragm and point of the sternum, to the convex upper surface or dorsum of the liver. This ligament is broadest where it passes down from the point of the sternum to the fossa umbilicalis; but, as it retreats backwards, it becomes narrower, and is united to the coronary ligament, near the passage of the vena cava. This circumstance, with the curve which it naturally takes on the surface of the liver, gives it the shape of the falx.

LIGAMENTUM TERES.—The round ligament of the liver is the firmer ligamentous cord, which may be traced from the umbilicus along the peritonæum into the duplication of the broad ligament, and into the fossa umbilicalis. It is formed by the degenerated coats of the great vein, which brings the florid blood from the placenta into the veins of the liver, and from thence into the right side of the heart of the fœtus.†

The CORONARY ligament of the liver is formed in consequence of the attachment of the liver to the diaphragm. The attachment is of course surrounded by the inflection of the peritonæum from the diaphragm to the liver. It is called the coronary ligament, though it has been observed that this attachment of the liver is not circular, but of an oval or very oblong shape.

The LATERAL LIGAMENTS are formed by the peritonæum continued laterally. The right lateral ligament, like a mesentery, attaches the right and great lobe of the liver to the diaphragm, and the left lateral ligament connects the left lobe with the diaphragm, and with the œsophagus and spleen.

FORM AND DIVISIONS OF THE LIVER.

The liver is convex and smooth on the upper surface; concave and more irregular on the lower part; thick and massy behind and towards the right side; but anteriorly and towards the left side it is thin, and has an acute edge, so that it lies smooth over the distended stomach.

GREAT RIGHT AND LEFT LOBES OF THE LIVER.—The first great division of the liver is marked on the convex surface by the broad ligament; which running back from the fossa umbilicalis divides it into the two great lobes, the right and left. When the concave surface of the liver is turned up, we see the same division into the right and left lobes, by a fissure, which runs backwards.

It is on this lower surface of the liver that we have to mark the greater variety of divisions in this viscus. Farther, it is on the right lobe that those eminences are to be observed, which, with the indentations and sulci, give some intricacy to this subject.

LOBULUS SPIGELII.‡—The lobulus Spigelii is betwixt the two greater

* Ligamentum latum suspensorium, falciforme.
† See Vol. I. p. 462. and Plan, p. 464.
‡ *Lobulus posterior — posticus — papillatus.*

lobes, but rather belonging to the right great lobe. From its situation deep behind, and from its having a particular papilla-like projection, it is called lobulus posterior, or papillatus. To the left side it has the fissure for the lodgment of the ductus venosus; on the right, the fissure for the vena cava; and above, it has the great transverse fissure of the liver for the lodgment of the cylinder of the porta: obliquely to the right, and upwards, it has a connection with the lower concave surface of the great lobe by the processus caudatus, which Winslow calls one of the roots of the lobulus Spigelii. Its situation is within the circle or bosom of the lesser curve of the stomach.

LOBULUS CAUDATUS.*— This really deserves the name of processus caudatus, for it is like a process of the liver, stretching downward from the middle of the great right lobe to the lobulus Spigelii. It is behind the gall-bladder, and betwixt the fossa venæ portarum and the fissure for the lodgment of the vena cava.

LOBULUS ANONYMUS† is the anterior point of the great right lobe of the liver; or others define it to be that space of the great lobe betwixt the fossa for the umbilical vein and the gall-bladder, and extending forward from the fossa for the lodgment of the porta to the anterior margin of the liver. Sometimes there is a projecting lobe on the margin of this part of the liver, and also there occurs a small projection on the left great lobe which acquires the name of LOBULUS LOBI SINISTRI.

SULCI, AND DEPRESSIONS OF THE LIVER.—On the lower surface of the right lobe there may be observed two slight excavations, formed, as it were, by the pressure of the colon and of the kidney. On the lower surface of the left lobe there may also be observed depressions answering to the convexities of the stomach and colon. But these are only the slighter irregularities which might pass unnoticed. There are, besides these, deep divisions which pass betwixt the lobes and lobuli, and indeed form these eminences.

UMBILICAL FISSURE.‡—From the anterior point of the two lobes there passes backwards to the left side of the lobulus Spigelii a deep fissure, which in the fœtus gives lodgment to the umbilical vein, and which in the adult receives the round ligament, where it is about to terminate in the left division of the vena portæ. The back part of this fissure gives lodgment to the ductus venosus in the fœtus. This fissure divides the liver into its two right and left divisions, and upon the right side joins the transverse fissure.

The TRANSVERSE FISSURE is that which passes above the lobulus Spigelii and lobulus quadratus; the processus caudatus, and the lobulus lobi sinistri. It is in this fissure that the great transverse division of the vena portæ lies.

The POSTERIOR FISSURE§ gives lodgment to the ductus venosus. It is a division in the posterior margin of the liver betwixt the left lobe and the lobulus Spigelii, and great lobe on the right. Sometimes, instead of the fissure or sulcus, there is a canal, as it were, in the substance of the liver.

* Processus caudatus.
† Lobulus accessorius — anterior — quadratus.
‡ Horizontal fissure, fossa longitudinalis, longa, anterior.
§ Or sulcus ductus venosi, the left fissure.

The fourth great fissure is that for the lodgment of the vena cava. It sometimes is called, in contradistinction to the last, the right fissure, or the FISSURA VENÆ CAVÆ. It is a large deep division betwixt the lobulus Spigelii and the back part of the right lobe, for receiving the vena cava as it passes up upon the spine.

The gall-bladder being sunk in the substance of the liver, the pit or excavation which receives it has been considered improperly as a fissure or fossa.* There likewise occur irregular fissures in the substance of the liver, which are like the cuts of the knife, and hold no regular place.

OF THE VESSELS OF THE LIVER, AND OF THE CIRCULATION OF THE BLOOD THROUGH IT.

There belong to the liver five distinct systems of vessels; these are, the vena portæ; the arteria hepatica; the vena cavæ hepaticæ; the lymphatics; and the biliary ducts.† These, with the nerves, form a very intricate system of vessels, but a lesson of the most particular importance to the physician. Before speaking of the connections which these vessels constitute with particular parts, or with the entire system, we shall take a view of their origin and course.

THE VENA PORTÆ.

This vein is divided into two parts; that which belongs to the intestines, and which, ramifying on the mesentery, receives the blood of the mesenteric arteries; and that part which branches in the liver, and distributes there the blood which it has received from the arteries of the membranous viscera. Even from this division, we see that the vena portæ has a very particular distribution; that while it is collecting its branches from the spleen, stomach, and intestines, like the veins in the other parts of the body, into a trunk, this trunk, instead of leading directly to the heart, or uniting with other veins in their course to the heart, enters the liver, and, like an artery, spreads into minute ramifications; hence it is called the vena arteriosa. It resembles an artery in this also, that it has no valves like other veins.

To be more particular, the vena portæ takes its origin from the extreme branches of the cœliac, upper and lower mesenteric arteries. The roots of the portæ answering to these arteries are the splenic vein; the gastro-epiploic vein which runs upon the great arch of the stomach; the mesenteric vein returning from the small intestines; and the right and middle colic veins, and internal hæmorrhoidal vein and left colic returning upon the mesocolon. These, answering to the three great branches of the abdominal aorta, pass obliquely upward in three great divisions, and unite with some lesser veins, as the coronary and smaller veins of the stomach, and pancreatico-duodenalis. The trunk of the vena portæ is now involved in the irregularly reticulated web of the he-

* It is generally called *fovea fellis*, or *vallicula vesiculæ felleæ*.

† And we might add, the arteries of the outer membrane of the liver which arise from the internal mammary, phrenic, epigastric, and even the spermatic arteries.

patic vessels, arteries, veins, glands, lymphatics, nerves, and biliary ducts, with their cellular membrane. It passes upward somewhat obliquely to the right, and enters the PORTA* or the sinus betwixt the processus caudatus and lobulus Spigelii.

When the vena portæ has entered the liver it divides into two great branches, which, running directly transverse, and being of large capacity, are sometimes called the cylinder of the vena portæ. Of these two great branches of the vena portæ within the liver, the right is greater in diameter, but shorter†: it ramifies in the great right lobe of the liver. The left is longer considerably, and filling the transverse fissure, it is reflected up into the umbilical or horizontal fissure, and is given to the left lobe, to the upper and more anterior part of the right lobe, viz. lobulus anonymus, and to the lobulus Spigelii.

The minute ramifications of the vena portæ every where pervade the substance of the liver, and inosculate with the veins of the surface belonging to the peritonæal coat. The blood of the vena portæ is received into the extremities of the venæ cavæ hepaticæ.

ARTERIA HEPATICA.

For the course of this artery, from the root of the cœliac artery to its entrance into the liver, see the description of the arterial system. The arteria hepatica and the venæ portæ are supported by the same sheath, the lesser vessel encircling the greater, like a tendril. While they have distinct functions, both terminate in the same returning veins; that is to say, whether we admit that one or both open into the biliary ducts, yet they have the same relation to the venæ cavæ hepaticæ which the arteries of the other parts of the body have to their returning veins.

VENÆ CAVÆ HEPATICÆ.

We have seen that the right auricle of the heart is close to the diaphragm above, and that the liver adheres to the lower surface of the diaphragm. We have also found that there was a groove in the back part of the liver for the transmission of the vena cava abdominalis. Now, as the vena cava ascending from the lower parts of the body to the heart is perforating the diaphragm, it is joined by two large veins from the liver, which, from their size and form, being the returning veins of the liver, are termed in general the venæ cavæ hepaticæ. These veins sometimes pierce the diaphragm, together with the cava abdominalis, so that there is to be observed one large perforation in the diaphragm; but generally they pass the diaphragm close to the great vein, but so that there are three openings in the diaphragm. When these hepatic veins are traced into the substance of the liver, they are seen to be gathered together from all parts of the liver in two, or sometimes three, great branches.

The communication betwixt the vena portæ and the venæ cavæ hepa-

* Sometimes it has been found divided before entering the liver. It has been also found to divide into three branches, in which cases (says Haller), two go to the left side.

† Into this branch sometimes the vein of the gall-bladder enters.

ticæ are so free, that several anatomists have imagined a peculiar and more immediate communication of their branches than holds in other parts of the body betwixt the arteries and veins; a circumstance which appeared to them the more necessary, considering the lesser impetus with which the blood flows in the vena portæ than in the arterial system.

BILIARY DUCTS.

The smallest subdivision of the substance of the liver is called acinus, and that molecule is supplied with a branch of the venæ portæ, arteria hepatica, and vena cava hepatica. With these there is also seen a minute ramification of the excretory duct of the liver. These last minute branches are the branches of the biliary duct; for they, running into each other, form trunks resembling the branches of veins, and these attaching themselves to the sides of the vena portæ form the greater trunks, answering to the right and left side of the liver. These two branches of the hepatic duct approaching each other, unite, and their union forms the hepatic duct, or ductus choledochus.

When the duct of the liver has advanced a little way from the transverse fissure, it is joined by the CYSTIC DUCT, or perhaps we should rather say, considering the use of the cystic duct, that it is reflected from the hepatic at an acute angle to the right side. The DUCTUS CYSTICUS is much smaller than the hepatic duct; it forms an acute curve near the gall-bladder, and takes a very sudden turn downward, as is seen in the marginal plate.

The hepatic duct, after being joined by the cystic duct, continues its course under the name of ductus communis choledochus, or common duct.* Now become somewhat larger, it takes its course under the head of the pancreas to the back part of the duodenum, about five inches from the pylorus.

Before it enters the gut, or more generally while included in the coats, it is joined by the pancreatic duct. Having pierced the muscular coat, it runs for some time in the cellular coat, in the length of the gut, and then opens upon the eminence of a considerable valvular plica of the inner coat.

This hole is regularly limited, and by no means equal to the diameter of the duct, either where it is contained within the coats of the gut, or in its course from the liver to the gut. Sometimes the hepatic and pancreatic duct open by distinct perforations.

The outer coat of these ducts is smooth and strong †: within this a cellular and nervous coat is described ‡, and muscular fibres imagined; but the inner coat is worthy of attention. It is reticulated in such a way, that a probe pushed up the duct is caught by their valve-like action.

* Ductus choledochus, hepatico cysticus.

† Although this coat resists in a considerable degree the distention of the duct, when blown into or injected, yet the whole coats are sometimes so distended as to admit the thumb. But this is rather to be considered as growth and enlargement, than distention.

‡ By Haller.

GALL-BLADDER.

We have already noticed, that the gall-bladder is attached to the lower surface of the right lobe of the liver, and partly buried in its proper sinus: it has sometimes occurred that it was merely suspended to the liver by a membrane like a mesentery. It is a bag of a pyriform shape; its greater end or fundus is contiguous to the colon; its lower end or neck to the duodenum.* It is generally of a size to contain an ounce, or an ounce and a half, of bile.

The coats of the gall-bladder are the outer peritonæal coat: a middle cellular coat, which from its analogy to that of the intestines we should call vascular coat; and an inner coat. In the intermediate coat muscular fibres have been looked for with great eagerness, but none have been demonstrated, although a conviction remains that there are muscular fibres in the composition of the coats of the gall-bladder. This coat gives form, limit, and strength to the gall-bladder. The third or inner coat is formed into innumerable rugæ, so as to take a cellular or reticulated texture. These loculi, as we may call them, thus formed by the duplicature of the internal membrane, are of considerable variety in shape, square, round, or triangular. These rugæ, and the whole internal membrane of the gall-bladder, have a beautiful and minute net-work of vessels upon them; and in these cells there can be little doubt that there are small mucous follicles or pores, or that an exudation from extreme vessels sheaths the surface from the irritation of the acrid bile. The extreme degree of vascularity and reticulated texture of this inner coat of the gall-bladder is not apparent before the sixth or seventh month of the fœtus, and then it takes a peculiar texture in preparation for the reception of the secreted bile.

Towards the opening of the bladder into the cystic duct the rugæ assume a semilunar figure, and seem to have a valvular action, in at least so far that they seem intended to give a degree of difficulty to the passage of the bile. The same structure of the internal coat prevails in the cystic duct.

However strange it may appear, considering the relation of the liver as a gland to its ducts, and to the gall-bladder as a receptacle of the bile, an opinion was entertained that the bile of the gall-bladder was secreted by its own coats, and that it was of a different nature from the bile conveyed from the substance of the liver. Without further argument it is sufficient to say, that when the cystic duct is tied, or when it is preternaturally obstructed, there is no bile secreted into the gall-bladder.

From the connections of the gall-bladder, and from the considerations of the whole anatomy, there can remain no doubt that the gall-bladder is a mere receptacle, reserving a sufficient store of this fluid for the due change to be performed upon the food; that as the stomach is not at all times loaded with food, nor the chyme and fluid from the stomach in-

* The gall-bladder has been observed wanting; in which case the dilated ducts would seem to have been capable of retaining a quantity of bile ready to be evacuated into the intestine. A double gall-bladder has sometimes been found.

cessantly passing through the duodenum, neither is the bile at all times running from the gall-ducts. On the contrary, as the stomach is emptied of its contents at stated intervals, the gall-bladder affords a provision for a quantity of bile to be evacuated proportioned to the food, which is passing the duodenum. Whehter we should conceive that this is a necessary consequence of the retention of the bile in the gall-bladder, or a provision of nature, I am uncertain; but it appears, that the longer the bile is retained, or the longer the fast and the deficiency of food in the duodenum, the more acrid and inspissated is the bile, and the greater also in quantity. This inspissation of the bile takes place in consequence of the activity of the lymphatics, which, ramifying on the coats, absorb the thinner part of the bile.

The rugæ of the inner coat of the gall-bladder may be a provision for extending the surface either for absorption or secretion; but I rather imagine that they are merely a provision for permitting extension more freely.

The gall-bladder is supposed, by some, to be emptied by the general pressure of the abdomen; an opinion founded on a mistake, which a very little consideration might correct. Some think that the stomach, or duodenum, or colon, being distended by the food, compresses and empties the gall-bladder; while others, with more apparent correctness, allege, that it is emptied in consequence of a consent of parts. With the latter I would confidently affirm, that as the aliment passes the duodenum, the bile follows apace, either from the alternate contraction and relaxation of the duodenum occasioning a relaxation of the orifice of the ducts, or, more probably, from the ducts being excited, as the salivary glands are excited by the presence of sapid bodies in the mouth. By want and hunger, the gall-bladder is allowed to be distended; there is no call for its evacuation.

Experiments would even teach us, that the gall-bladder has not the same irritability, excitable by stimuli applied to the coats, which the stomach, intestines, or bladder of urine have; which is a proof that, like the iris and many other parts of the body, its action is roused more powerfully by indirect stimulus, and through consent of remote parts, rather than by the distention of its coats: whereas the intestines and bladder have it in their constitution to be excited to contraction by simple distention.

From experiments it would appear, it confirmation of what is here alleged, that while the food is in the stomach little bile is discharged; but that it flows when the matter is passing the duodenum, so that a great quantity is then found in the gut. On the contrary, in a state of want and hunger, the gall-bladder is greatly distended, and yet little bile flows from it; although it is not only more in quantity, but more acrid and bitter.*

That the gall-bladder is not destitute of irritability and the power of contraction, would appear from many cases, where, like the urinary bladder, it contracts upon concretions, and becomes thick in its coats.

The retention of the bile, surcharging the ducts, and distending the gall-bladder, and the sudden discharge of accumulated bile, and the ir-

* Anat. generale de Xav. Bichat, tom. iv. p. 6.

regularities of its course when influenced by disorder of the viscera, are the sources of the most severe and distressing symptoms.*

In the dead body we see the colon and duodenum, or whatever parts lie in contact with the gall-bladder, stained with bile; but this evidence of transudation which is found in the dead body is not seen in the living; while the stain from the bile is observed to be deeper and more extensive in bodies some time dead. It is therefore another example of the peculiar property inherent in the living fibre, which prevents transudation†; the fluids which appear as if exuding from the living surfaces are really discharged from organic pores, or from the extremities of vessels by a living property.

OF THE MINUTE STRUCTURE OF THE LIVER.

The liver is firmer and dryer in some degree, than any of the other viscera; the intertexture of membrane is weak, and in consequence the substance of the liver is friable and easily torn; I have seen death many times from rupture of the liver, consequent on falls and shocks. When cut or torn, it seems for the greater part vascular; or it displays the mouths of innumerable ducts and vessels, and, after a minute injection, the blood-vessels seem to pervade every particle, even when examined with the microscope.

This texture of vessels, in which we may say the substance of the liver chiefly consists, is surrounded with a delicate membrane, the continued peritonæum. It retains the character of peritonæum, in being a simple membrane, whitish, and a little pellucid. In this membrane minute arteries and veins ramify, which are unconnected with the internal system of vessels. In the close cellular membrane beneath it the lymphatic vessels take their course.

When a section is made of the liver, the vessels may be distinguished: the ducts by the thickness of their coats, and their yellow colour; the arteries by a less degree of thickness, and a more resisting elasticity; the

* We have examples of this in a Treatise on the Diseases of the Bowels of Children, by Dr. Cheyne.

A veterinary pupil has just informed me of some experiments he has been making. He destroyed sensation by injuring the medulla oblongata. He then opened the abdomen, and the dog being kept alive by artificial respiration, he saw the peristaltic motion of the intestines very distinctly; but on tying the gall-ducts, these motions soon ceased. This must be confirmed by further observation.

† The peculiar odour of the intestines of a dead body is not perceptible in the living: when in dissection the fingers touch the intestines, they retain the odour long; but on handling the intestine in the operation for herniæ, the bad smell does not attach, nor is it at all perceptible. Poison in the stomach of an animal will pervade the coats and affect the whole substance, if permitted to remain after death: but if the stomach containing the berries of the lauro-cerasus be taken from the pheasant of America, they are wholesome food. The peccary, or Mexican hog, when killed, must have the dorsal gland immediately cut out, or the disagreeable smell of this secretion makes the flesh unfit to be eaten. For the same reason, the Indians cut away the noxious glands from the Skunk immediately when killed. All these examples show that the living substance resists the contamination, but that when the parts are dead they no longer resist the percolation of the fluid, the colouring or odorous matter.

For much of the anatomy of the liver, and of the bile, see Morgagni Adversar. An. iii. A. xx. to xxvii.

branches of the vena portæ and the cavæ hepaticæ by the thinness of their coats, of which those of the latter are considerably the weaker.

The vascular tissue of the body of the liver has no communication by vessels with the investiture of the peritonæal coat of the liver.* It is therefore considered as a peculiarly distinct organization. By proofs drawn from anatomical injections we are informed that there is a free intercourse through the extreme branches of all the five systems of vessels in the liver. By making minute injections and sections of the liver, there seems no likelihood of gaining information of the structure and connections of these vessels. Walther, who seems to have examined this matter more methodically and minutely than any other anatomist in any age, could make no distinction of parts. In whatever way he made his sections, whatever system of vessels he filled, whether the whole vessels or each separately, he could not ascertain the direction and course of any particular vessel, nor its inosculations, but all was obscure, and as if constituting one chaotic mass. In wet preparations, however, he observed that the extreme branches of the hepatic artery opened into the vena portæ: that the branches of the vena portæ had a double termination; that some of them, by a sudden turn and serpentine course, terminated in the branches of the venæ cavæ hepaticæ†; while others were seen to terminate or open into the biliary ducts. Further he observed, that in all the branches of the vena portæ there was a peculiar compressed appearance which distinguished them from all the other vessels of the viscus.

Intersections of the intimate membrane of the liver, which divides and subdivides the fasciculi of vessels, have been observed. These are, however, somewhat obscure and indistinct. The last perceptible subdivisions of the substance of the liver have been called ACINI‡: and they are rather presumed than directly proved to have in their composition an extreme ramification of the several vessels of which the liver consists.§

We have seen that Malpighi conceived that these bodies were simple glands collected on the ramifications of the vessels; that they were little vesicles; and that from them the pori bilarii took their origin. In this opinion he was successfully opposed by Ruysch, who affirmed that they were vascular; and in this opinion he has been supported by Albinus. It would, in truth, appear that the description of these partitions of the substance of the liver, and the ultimate subdivision of it into these little grains, about which there has been so much controversy, is not founded in an accurate observation, and that there are neither cryptæ, hollow and cellular, nor little bodies made up of convoluted arteries, but the minute parcels of vessels, which are collected together and united by fine cellular texture; they may be called acini, according to the definition which has been given in the introduction.‖

* Sœmmerring. Walther, loc. cit. &c.

† I should imagine that in this he might have been deceived by the lesser branches of the portæ (filled with injection) opening into the side of the larger trunks; and that there is no such termination of the hepatic arteries in the sides of the vena portarum, so that their open mouths are discernible.

‡ See the definition in the introduction to the anatomy of the viscera.

§ Acinos nemo rejicit, ne Ruyschius quidem, sed de interiore fabrica disputatur. *Haller.*

‖ Finally, Ruysch's opinion may be given in these words (Epist. ad Virum Clar.

OF THE FUNCTION OF THE LIVER, AND OF THE SECRETION OF THE BILE.

Notwithstanding that the circumstance of the biliary duct being discovered points to one very obvious use of the liver, yet I am not satisfied that our knowledge of its functions is nearly perfect. In animal bodies one organ ministers to several functions. As the tongue is the organ of taste, of speech, of deglutition; as the lungs minister to respiration, to circulation, to speech, to smelling; as the skin serves many purposes; so I believe that we are too easily satisfied with discovering one use of the liver, in secreting the bile and stimulating the intestines.

The great size of this gland would impose upon us the belief that it serves some very important use in the animal economy, and the state of the system which originates with the disorder of the biliary secretion strengthens that belief. The function which it performs is probably the separation of some form of useless carbon; as M. Fourcroy has taught, that the bile is formed in a great measure of the combustible matter of the blood, thus making the liver a true auxiliary of the lungs.

Upon reviewing the whole system of the liver the peculiarities in the vena portæ strike us the most. It occurs to us that this great supply of blood to the liver, with the slow motion peculiar to venous blood, after having gone the circulation through the intestines, is a provision for the discharge of carbon and for the secretion of the bile. It is believed, that the secretion of bile is made from the blood of the vena portæ.

But as we see that this blood distributed by the branches of the vena portæ in the liver must be so far exhausted as to become incapable of all the uses accomplished by the arterial blood in other glands, we must look for another supply. We must be sensible, although the vena portæ be peculiarly adapted to secrete the bile, it is not capable of supplying nutrition and energy to the substance of the vessels of the liver, and that there is therefore a necessity for arterial blood being sent to this gland through a branch of the arterial system. We have had occasion to remark, that no part retains its function in vigour, nor the living properties which belong to it, unless the arterial blood be circulated through it. Therefore it would appear necessary that the arteria hepatica, a branch of the aortic system, should be given to this viscus. This artery performs the same office here in the liver that the bronchial arteries do in the lungs, or the coronary arteries in the heart, or the vasa vasorum in the great vessels. The pulmonic artery carries venous blood into the lungs, which, having returned from the circulation of the body, cannot send off smaller branches to supply the membranes and vessels of the lungs; it is necessary that for this purpose branches of the aortic system

Her. Boerhaave, p. 69.): "Sed nolo diutius tergiversari, fateor ergo, quod, quando primo incipiebam me exercere in anatomicis, videbam tunc quidem, quod in jecore humano se ostendebant acinuli parvi innumerabili numero, quæ tum temporis appellabantur glandulæ; nam nemo cogitabat aliter sed manet sola jam hæc questio, an acinuli hi hic hærentes sint glandulæ simplicissimæ, folliculi cavi cum emissario an quid aliquid? dico nemo demonstravit illos tales esse ut hic assumis. Imo vero facile jam erit demonstrare, acinos hos cum criptis antea pertractis nihil commune habere: quia oculis nostris non apparent ut membranulæ cavæ et quia etiam non habent emissarium. Sed componuntur tantum ex extremitatibus ultimis vasculorum sanguiferorum unitis in formam spheræ rotunditatis, neque, quantum possum videre etiam membranula aliqua sua singulari circumambiuntur."

shall enter the lungs. Again, in the heart the blood contained in its ventricles is incapable of supplying its substance; or the blood coming through the canals of the great vessels cannot be the means of ministering to the active powers of their coats: but for this purpose the vasa vasorum are distributed through the coats of the vessels. These vessels, therefore, bear an analogy to the arteria hepatica in the liver.

We must not, however, suppose that this scheme of the action of the vascular system of the liver, however rational and simple, will be universally allowed. Indeed there are circumstances which seem to stand in opposition to it. Of these the most interesting is the case of unusual distribution of the vessels of the liver communicated by Mr. Abernethy.

The subject was a female infant, which was supposed to be about ten months old. Among other varieties it was observed, that the branch of the cœliac artery distributed to the liver was larger than common, and exceeded by more than one third the usual size of the splenic artery. This was the only vessel which supplied the liver with blood for the purpose of either nutrition or secretion. The vena portarum was formed in the usual manner, but terminated in the inferior cava nearly on a line with the renal veins. The liver was of the usual size, but had not the usual inclination to the right side of the body: it was situated in the middle of the upper part of the abdomen, and nearly an equal portion of the gland extended into either hypochondrium. The gall-bladder lay collapsed in its usual situation. It was of a natural structure, but rather smaller than common. On opening it there was found in it about half a tea-spoonful of bile. The bile in colour resembled that of children, being of a deep yellow brown, and tasted like bile, but it was not so acridly bitter and nauseating as common bile.

Mr. Abernethy remarks upon this case, that when an anatomist contemplates the performance of biliary secretion by a vein, a circumstance so contrary to the general economy of the body, he naturally concludes that bile cannot be prepared unless from venal blood; and he also infers, that the equal and undisturbed current of blood in the veins is favourable to the secretion; but that the circumstances of this case, in which bile was secreted by an artery, prove the fallacy of this reasoning.*

We may observe on this case, that it does not prove the bile to be, in the natural economy, secreted by the arteries and not by the vena portæ; for the artery here was unusually large, so that it performed a function in this instance which it does not usually perform. Had the artery been of the usual size, we might then have concluded that the vena portæ was distributed to the liver to serve some lesser use in the economy of the system, and that it did not secrete the bile.

The liver, it is said, was of the ordinary size. Now as the bulk of the liver is, in its natural state, made up of the dilated veins, it is some proof of what I should imagine had taken place here, that by some provision of the vessels, the arterial blood had been diffused, and the celerity of its motion checked previous to its ultimate distribution. Nay, it may have opened into the branches of veins answering to the extremities of the vena portæ.

* See Mr. Abernethy's case, of uncommon formation of the liver. Phil. Transactions.

In the deficiency of the acrid and bitter state of the bile there is in this case evidence that the bile formed from the arterial blood is unlike the perfect secretion. I conceive this opinion to be countenanced by the peculiar circulation of the blood in the liver of the fœtus, and by its effects upon the secretion. We have seen in the fœtus, that almost the entire gland is supplied with arterial blood returning from the umbilical vein; and the natural deduction from this is, that this is the cause why the bile in the fœtus is of a less stimulating quality, and smaller in quantity, than in the adult.

I conclude, that this singular and interesting case* may strengthen the opinion which some have entertained, that the extreme branches of the hepatic artery pour blood into the extremities of the vena portæ previous to this formation of the bile by these veins; but it still leaves us with the general conclusion, that the peculiarities in the distribution of the vena portæ are a provision for the secretion of the bile, and that the branch of the aortic system, the hepatic artery, is otherwise necessary to the support of the function of the liver.

Finally, as to the use of the liver independently of the secretion of the bile, we must lay aside the opinions mentioned by Haller, that it supports the diaphragm, pushes it up in expiration, and receives the contraction of it equally in inspiration, so as uniformly to compress the other abdominal viscera; or that it foments and cherishes the stomach by the heat of its blood. These are at least as bad as the theories of the ancients mentioned in the beginning of this section. Haller sometimes puzzles us by the promiscuous admission of all facts and every kind of theory, with something of indecision in giving his own opinion.

There is another remark of Haller which deserves attention. "When I reflect," says he, "that there is no bile required in the fœtus, there being no food received; when, again, I see that the liver is of great size in the fœtus, and not small like the lungs, which are destined to an operation in the economy after birth, I cannot but suspect that it has some other use in the fœtus than the secretion of the bile." If the umbilical vein had opened directly into the cava, he thinks it would have returned with too great an impetus upon the heart, and would by its preponderancy have retarded the return of the blood from the lower extremities. He thinks that the liver is useful in breaking and weakening the impulse of the blood from the umbilical vein; that it is a guard to the right auricle, which would be otherwise endangered by the rapid flow of the blood. Now, surely the liver is much less able to stand the impulse of the blood than the heart; and yet there is no provision for the breaking of the force of the blood in the liver. Further, there is a direct duct of communication leading to the heart. There is no reason to believe that the umbilical vein carries back the blood with greater force than any other returning vein; on the contrary, from its size and the length of its course, it is natural to suppose the motion of the blood in it to be very slow and equable.

We must look upon the peculiarities in the circulation of the blood in the liver of the fœtus as a provision against the secretion of stimulating bile; for when the child is born and the circulation altered, bile is formed

* I had a preparation, now in Edinburgh, where the liver wanted the hepatic artery.

more abundantly, and becomes the stimulus to the whole abdominal viscera, rousing them to new action. As to the comparison which Haller has made between the state of the liver and that of the lungs, it is evident that the latter, though small in bulk, are fully formed, and want only inflation to complete their function. In the liver of the fœtus the vessels are distended with blood, to give them the size requisite for this future function ; but that blood, either from its qualities or from the easy and direct passage it has into the heart, does not secrete the bile of a quality to stimulate the ducts and intestines, as in the adult circulation. If it did, we should not see the alimentary canal of the fœtus loaded with green matter, and the whole canal in a state of inactivity and torpor.

The natural bile of the adult system is of a deep yellow colour: when concentrated by the absorption of its liquid parts it is brown : sometimes the bile of the gall-bladder is green, although there has been no disease in the liver. To compare it with something familiar, the bile is of the colour of wetted rhubarb. As to the use of the bile, the more common opinion is that it precipitates the feculent matter from the chylous fluid. But for this there is no other foundation than that such a separation does actually take place ; but we have bestowed that action on the villous coat of the intestine,—with what show of reason may be seen above.

Mr. Hunter was of opininon that this bile did not incorporate with the chyle ; it certainly does not confer on that fluid its sensible qualities, though it may be possible, according to the opinion of M. Fourcroy, that the alkaline and saline ingredients of the bile may combine with the chyle, while the albumen and resin may combine with the excrementitious matter.

If the bile was a mere excretion, if it were poured into the intestines merely to be thrown off, then the duct would have entered into the lower part of the gut, into the colon, and not into the duodenum.

Neither would we have observed that connection betwixt the state of digestion and the discharge of the bile into the intestine, which I have already noticed.

Perhaps we may conclude, that the liver linked in close sympathy with the intestines, connected by nerves, by blood-vessels, and by ducts, holds a control over their action by the stimulating fluid which it supplies to them.

OF THE PANCREAS.

The pancreas is a gland, the largest of those which have been called the conglomerated, that is, distinctly consisting of lesser parts united. It is of a long form like a dog's tongue, and lies across the spine, and behind the stomach. Its excretory duct opens into the duodenum.

The pancreas is confined betwixt the two laminæ of the mesocolon, and it is united to them by a loose cellular membrane ; it lies before the great mesenteric vessels, with its posterior face upon the spine and aorta, and covered anteriorly by the superior lamina of the mesocolon. It is

divided into the head, body, and extremity. The head is towards the right side: its small extremity touches the spleen, and is near the capsule of the left kidney; but towards the right extremity it increases gradually in massiness, until its head lodges upon the duodenum. It is like the salivary glands in its appearance, consisting of lobules successively smaller and smaller; and it also resembles them in the manner in which its duct is formed. The duct* begins towards the left extremity by exceedingly small branches: these running together form a middle duct, which taking a serpentine course towards the great extremity, and increased by the accession of the lateral branches in its course, becomes nearly of the size of a writing quill. Towards the right, the head of the pancreas is irregular, and indeed a lesser pancreas generally projects from it. Approaching the duodenum the duct unites to the biliary duct, and opens along with it into the duodenum. A valve has been described as in the extremity of the pancreatic duct, but it is certainly incapable of the action of a valve, as the bile has been found to have gone retrograde into the trunk of the pancreatic duct. Sometimes there are two pancreatic ducts, but more frequently the part of the gland next the duodenum, and which is called the round head of the pancreas, has an excretory duct peculiar to itself, which either opens into the duodenum separately from the main duct, by piercing the coats of the intestines nearer the stomach, or sometimes opens further down. In the dog there are distinctly two ducts, the one opening into the biliary duct, the other separately into the duodenum.

De Graaff, Ruysch, and many others have made experiments to discover the nature of the secretion from the pancreas. Tubes were introduced into the ducts, and bottles were appended to them in living dogs, so as to catch the pancreatic fluid: it was found ropy, insipid, and like the saliva. It has therefore been concluded, from the colour, structure, ducts, and secretion of the pancreas having so strict a resemblance to those of the parotid and submaxillary glands, that it is of the nature of the salivary glands of the mouth. The general opinion has been, that it is useful in secreting a fluid which dilutes and moderates the acrimony of the bile. More accurate chymical examination of the pancreatic fluid has not been made, or has not been successful in showing any peculiarity in it.

Considering the pancreas as a salivary gland, how great must be the quantity of fluid poured out by it, if, as we are entitled to do, we take the analogy of the parotid, submaxillary, and sublingual glands! These salivary glands, although they may be said to surround all the jaws from the zygomatic process on either side, are nothing in massiness and size to the pancreas. Again, the pancreas is most plentifully supplied with blood-vessels. Besides lesser branches of arteries, the pancreatico-duodenalis gives two branches, which take an extensive course through it, and are joined by other mesenteric twigs; and twigs proceed from the vessels of the stomach, and even from the hepatic artery; but more particularly we have to observe the large branches bestowed upon it by the splenic artery, where it takes its course close upon it.

While the masticators are working, the parotid gland pours out so great

* Ductus Virsungi.

a quantity of saliva, says M. Helvetius, that it is inconceivable, and what I should not believe, had I not seen it in a soldier of the guards. A cut with a sabre in the cheek had opened the salivary duct: the wound healing on the inside of the cheek left a fistulous discharge from the parotid duct. When he ate, there flowed from this hole a great abundance of saliva: so that during dinner, which is not long in the Hôtel Dieu, it moistened several napkins. How much must flow from all the salivary glands! how much from the pancreas, which is greater than them all collectively!

The pancreas being supplied with arteries from the splenic artery and duodenal artery, it must partake of the increased circulation of blood, while this system of vessels is excited by the fulness of the stomach. By this it must be prepared with an increase of secretion proportioned to the food passing the pylorus.

It is probable that the contents of the stomach when passing the duodenum, or the bile flowing from the biliary ducts, become the stimulus to the discharge of the pancreatic fluid: and as we see that the morsel in the mouth will quickly produce an almost instantaneous secretion and discharge of saliva, so we are led to conclude that the flow of pancreatic fluid may be as suddenly produced without the necessity of a reservoir, as in the biliary system. We naturally conceive that the effect of this fluid is to diminish the viscidity of the bile, and by diluting it, to mix it uniformly with the food. There are, however, few facts to enable us to reason on the effects of the pancreatic fluid. If we give full credit to the experiments of Malpighi and Brunner, we may conclude, than when the pancreas is taken away, the more acrid bile causes vomiting or voracious appetite by its stimulus. Scirrhus of the pancreas has been found attended with a costive and slow motion of the intestines; which seems to contradict the result of these experiments on animals: but by the scirrhosity and enlargement of the pancreas the biliary ducts may have been more or less compressed, and the retardation of the usual quantity of the biliary secretion might produce the slowness of the bowels.*

On the whole, I am inclined to think that the pancreas is a gland of dilution merely, that the flow of its secretion will depend on the state of the food or of the bile passing the duodenum. That, as in drinking, the saliva is not excited to flow, neither is the pancreatic fluid, when the matters descending through the duodenum are bland and liquid, but when they require dilution this gland is ready to afford it.

* According to the hypothesis of Silvius, the use of the pancreas was to supply an acrid spirit or juice: and the biliary secretion being of the nature of an alkali, these two struggling together caused the separation of the chyle from the fæces. The struggle did not stop here, but these enemies being carried into the blood, continued their warfare in the heart itself, and lighted up the vital flame there.

Nay, if we believe the experiment of M. Schuyl (de Veteri Med.), this hypothesis was not without its proofs; for having tied in the portion of the duodenum of a living dog, where the pancreatic and biliary ducts enter, he saw the ebullition from the struggle of the acid and the alkali; and when he compressed the hepatic duct, the tumefaction of the intestine subsided; when he took off this compression, it was again blown up. As this experiment has not succeeded since, as Haller observes, Schuyl was probably deceived by the peristaltic motion of the intestines.

OF THE SPLEEN.

The spleen is a viscus of an irregular, oval figure, and dark purple colour. It is attached to the great extremity of the stomach. It is soft in its substance; and has the peritoneal coat very delicate. We should be glad could we say, with the old anatomists, that it is of a parenchymatous structure, for in truth little is known of its organization.

In treating of this subject we must be indulged in some speculation; and, indeed, it is privileged ground; for the history of the opinions regarding the supposed function of the spleen is full of loose conjectures or wild hypotheses, and nothing is as yet certainly known of its use.

SEAT AND CONNECTIONS.

The spleen is seated in the left hypochondrium; above the left kidney; and under the protection of the false ribs; and of course it is under the edge of the diaphragm. It is connected with the stomach by the cellular membrane, by the omentum, and in a still more particular manner by the vasa brevia. It has also connections with the left extremity of the pancreas by cellular membrane, and the branches of the splenic vessels. Lastly, it has a firmer attachment to the diaphragm, by means of a ligament formed by the peritonæum.*

The spleen is of an irregular figure. Where it is contiguous to the diaphragm it is uniformly convex: towards the stomach its surface, while it is hollowed out and concave, presents two sides, so that we say the whole mass is somewhat of a triangular form. The anterior edge of the spleen is notched with deep sulci; behind, and at the upper part, the margin is large and round.

The substance of the spleen is the most spongy, tender, and soft of al-the abdominal viscera; so much so, that not only does the finger make an impression upon its surface, but it actually disorders and tears its vessels. After a successful injection the whole seems made up of vessels; and if any thing like acini or globules are to be observed, the microscope will show them to be accidentally produced by the fasciculi of vessels. By injecting the vessels of the spleen with wax, and corroding it, granules of wax are seen on the extremities of the veins as if they had filled cells; and when blown up, dried and cut, the cells appear to be continuous and regular. The cellular texture, uniting the vessels of the spleen, assume a remarkably stellated appearance. Upon the whole, this viscus has a resemblance to the substance of the placenta. The spleen is seldom smaller than natural; often greatly enlarged.† I have seen it equal to the liver in size, and filling the whole left side of the belly. It has been frequently found thus enlarged, with-

* Yet the spleen is very apt to change its situation, or to fall down from under the protection of the false ribs. It is liable to enlargement. From which circumstances it will not be wonderful if it is wounded in tapping for the ascites. See Monro on Dropsy. Lienis a statu suo deviatiônes, Sandifort, Thesaur. vol. iii. L. Baader observationes variæ. Albinus Acad. Annot. lib. vii. cap. xiv.

† For varieties in size and form, see Morgagni Advers. III. Animad. XIX.

out any peculiar symptoms indicating such a disease during life. From its soft texture and great vascularity, like the liver, it has been found rent by blows and falls*; and wounds here, as in the liver, by opening the large vessels are suddenly fatal. Sometimes it is hard and scirrhous: it is subject to inflammation, to ossification, and to have tubercles formed in its substance. There is seldom suppuration in it. The spleen has been observed to swell up and enlarge when the stomach is empty, and to be contracted when it is full. It has been observed, that it is large and spongy in those who have died a lingering death, or who have been long ailing; that, on the contrary, it is smaller and firm in those who have died suddenly a violent death.

We are informed, that the blood of the splenic vein is peculiar, insomuch that it does not coagulate like the blood in the other veins of the body.†

That which, more than any other circumstance, excites our attention, is the great size of the blood-vessels of the spleen. Both the splenic vein and the artery are of great size in proportion to the bulk and weight of the spleen; and in their course they are particularly tortuous. I conceive we may also draw consequences from the distribution of their branches to the stomach (viz. the vasa brevia and left gastro-epiploic) and to the pancreas. Its lymphatics are numerous. It is supplied with nerves, but has very little common sensibility. It has no excretory duct.

Professor Coleman made experiments on dogs, and found that when they were deprived of the spleen, they became fat and indolent. An old pupil has lately given me an account of his cutting off the spleen in a native of South America. The spleen, escaping from a wound, had become gangrenous. He could observe no effect to result from this extirpation.

Opinions regarding the use of the spleen.—Of the various uses of the spleen, the lowest conjecture, in respect to ingenuity or probability, is, that like a sand-bath, it foments the stomach, and promotes the process of digestion. This notion is, perhaps, not inferior in absurdity to that opinion, which ascribed to the spleen the office of forming an acid juice, which, being carried by the vasa brevia into the stomach, was supposed to excite the appetite.‡

It was a better conception that the spleen is the seat of melancholy; "that moping here doth hypochondria sit:" or of "laughter holding both his sides,"—of which the holding of the sides was the evidence. And again, since tickling the ribs is a demonstration of the effect from

* I have seen death from rupture of the spleen, by a wound which never penetrated the abdomen: a pistol shot entered the chest and struck the diaphragm without piercing it; the lad died with effusion in the belly; and, on examination, the spleen was found burst by the contusion.

† With regard to this point I have no opinion, having hitherto neglected to examine the fact. The experiments of Sir Everard Home countenance the opinion.

‡ I am mistaken in calling this the lowest in absurdity. The spleen has been considered as the seat of the soul! the cause of venereal appetite! the gland which formed the mucilaginous fluids of the joints! The atrabilis was received here, concocted and transmitted to the liver. It drew forth and formed blood from the stomach, &c. Other physiologists, not contented with the theories presented to them, and yet incapable of suggesting others more likely, have very modestly asserted that the spleen was of no use at all.

this excitement of the spleen*, that the growth of the spleen promotes laughter to such a degree, that it becomes a permanent silly simper. Nay, further, we have authority for the excision of the spleen from those who are otherwise incurable in their propensity to laughter, an operation which promises certain success!

The following is a theory which has been very commonly received. A great quantity of blood is imported into the spleen with a slow motion, owing to the serpentine course of the vessels. When the stomach is empty, the blood is received in a greater quantity by the spleen, where it has an opportunity of stagnating. Here the blood, fomented, attenuated, and in a manner dissolved by the neighbourhood of the putrid fæces in the colon, enters upon the first stage of putrefaction. By this resolving of the blood it is made more fluid, in which state it is returned by the veins, there being no excretory ducts. Now when the spleen is compressed between the distended stomach and the ribs, and the contracting diaphragm, the blood is pressed out from it in greater quantity and celerity towards the liver, mixing with the sluggish blood in the trunk of the vena portæ; replenished with the fat and oil of the omentum, it dilates that vessel, and prevents the stagnation and congelation of the blood. In short, the spleen has been supposed to be subservient to the function of the liver, and to the preparation of a watery (and subalkaline) fluid to the blood of the portæ, all which is unfounded conjecture merely.

Another opinion has been, that it counterbalanced the mass of the liver seated to the right side of the belly.

Hewson entertained a theory regarding the use of the spleen, which is injurious to his reputation. He conceived that the spleen added the flat vesicle of the globules of the blood: his only observation in way of proof was, that he saw a few red globules returning by the lymphatics of the spleen: the effect, I have no doubt, of the injury of its substance, or of the compression of its vessels. It seems to me strange that such a man, seeing the large splenic artery throwing its full tide of perfect arterial blood into the spleen, full of globules, complete in every respect, and again seeing a few globules carried back by the lymphatics, should imagine that this artery formed these few vesicles, with which it was already so fully charged.

That the stomach, duodenum, liver, pancreas, and spleen, are united in function, I have no doubt. Nature has placed them, not only in juxtaposition, but has united them by the same entanglement of nerves, and has given them the same system of vessels. The cœliac trunk supplies them all.

Further, I conceive the spleen to be an organ subservient to the stomach; and not only the constant attachment of it to the stomach in the human body, but the frequency of its attachment to the stomach in the lower animals, confirms the opinion. I regard it as a provision for giving the vessels of the stomach an occasional power and greater activity, enabling them to pour out a quantity of fluid proportioned to the neces-

* "Risus in liene sedes videtur ex effectu titilationis nataque in plurimis mortalibus risum excitat," &c. Haller. His sober objection is, that tickling the right side will do as well as the left.

sity of the digestion. In the first place, let us examine the course and form of the splenic artery, and I think we shall find the great peculiarity of its size, and tortuous form, and strong coats, a provision for occasional great increase of power; while, if not roused by the peculiar sympathies which actuate it, it is of a form to retard and weaken the velocity of the blood. This is founded on these propositions:—

1. The muscular power of an artery increases as it recedes from the heart; the elastic power diminishes.

2. An artery, the nearer it approaches to its final distribution, is the more immediately under the excitement and control of the organ; is active when the organ is excited; is, relatively speaking, quiescent when that organ is not called by its sympathies to exercise its function.

3. An artery tortuous in its course has more muscularity and greater power of action than one which takes a straight course; but in proportion to the increase of power which it obtains by its increase of length in this tortuous and bending course, will these turns retard and weaken the force of the heart upon the extreme ramifications of the vessel.

Thus a tortuous artery is the means of increasing the velocity of the blood by its own action, but it makes the organ less dependent on the general force of the circulation. We accordingly find, that in those organs where there is occasional activity alternating with a quiescent state, the artery is tortuous; and where there is an increase of force required in the circulation, there the artery, from being straight in its course, becomes crooked and twisted in every way.*

From these remarks, we may be inclined to draw, from the tortuous figure of the splenic artery, a conclusion somewhat different from that which has hitherto been deduced. We may conclude, that it is not the means of retarding the blood in its circulation, but of giving force to it. The splenic artery does not only ramify in the spleen, but it supplies all the left part of the stomach, and that great sacculated extremity in particular which receives the food, and in which the process of digestion is chiefly performed. My idea is, that when the stomach is empty, when there is no food in it to solicit the discharge of the gastric fluid, the blood circulates in a moderate degree in the coats of the stomach, and the spleen receives the surcharge of blood; but when a full meal is taken into the stomach, when the action of the gastric juice is required in great quantity, the action of the splenic artery is solicited to the vasa brevia and left gastro-epiploic artery, and thus a sudden flow of the gastric fluid is bestowed by the increased activity of the splenic artery. When, again, the contents of the stomach are fully saturated with the fluids from its coats, there is no longer an excited action of the splenic vessels, and the artery terminating in the veins, the spleen returns the blood to the liver. While the vessels of the stomach partake largely of the supply of blood, the arteries to the pancreas also receive some in-

* This has been supposed to be the effect of the impulse of the blood, but nothing can be more false. Let any one examine the artery of a limb when a great tumour is growing; the artery will be found tortuous to supply it. Again, in the aneurismal varix, where there is a breach in the artery, and the blood finds a freer return to the heart, the artery will be found enlarged and tortuous in order to supply the lower part of the limb; while there is a quantity of the blood withdrawn from the circulation by the communication with the vein.

crease of activity; and the blood of the vena portæ requires an additional supply and activity.

I leave this opinion of the vascular system of the spleen, as expressed in former editions, and with the conviction that I have assigned one use of the splenic vessels, and afforded an explanation of their tortuous form; but these remarks do not explain the structure of the body of the spleen.

That there are cells in the spleen is very generally believed, and that some operation, connected with the economy, is performed there, is also a general belief. Sir Everard Home was of opinion, at one time, that the spleen drew the fluids from the stomach, and delivered them into the circulation. But finding that infusions of rhubarb got into the circulation from the stomach when the pyloric orifice was tied, and the spleen taken away from the animal, he gave up that opinion. But he has made experiments which lead to the belief that a secretion is poured into the cells of the spleen; but for what purpose there are these cells or this secretion is still conjecture.

The probability is, and it amounts to no more, that the venous blood of the spleen is useful in the function of the liver. Either it may supply venous blood in proportion to the wants of the liver, or in that venous blood carried to the liver there may be some peculiar change wrought by the spleen, and fitting it for the secretion of bile.

OF THE URINARY ORGANS.

OF THE KIDNEY.

Under the head of urinary organs, we enumerate the kidneys, ureters, bladder, and urethra. The kidneys are distinct from those parts which have hitherto engaged us, as they secrete the urine, and form therefore the link betwixt the viscera of the abdomen and those of the pelvis; for though lying in the abdomen, they are more strictly connected with the parts in the pelvis. The structure of the kidney forms a very interesting subject of enquiry; because it is the field of dispute betwixt the contending parties regarding the structure of glands and the theory of secretion. It is chiefly from the kidneys that the facts are drawn in illustration of the opinions of Malpighi, Ruysch, and all the others.

Form, seat, and connections.—The kidneys lie on each side of the spine, and betwixt the spine of the ilium and the lowest ribs. It is sunk, as it were, in the fat of the loins, and by that means attached to muscles of the loins; it rests in part on the lower part of the diaphragm; which last connection is the cause of the pain felt in respiration during inflammation in the kidney. The right kidney is placed somewhat lower than the left, which is owing to the greater size of the liver on that side.

The kidneys are without the abdomen, that is to say, behind the peritonæum, as shown above; for the kidney lying close upon the muscles of the loins, the peritonæum is merely stretched over it. This is the reason why calculi in the kidney have wrought themselves out by fistu-

læ in the loins; and it is the ground of the hazardous, indeed absurd, proposal of cutting into the kidney to extract calculi.*

The adipose membrane surrounds the kidney, and forms a kind of capsule; for it is this which is sometimes in an extraordinary degree loaded with accumulated fat. Upon this capsule the cæcum is attached on the right side, and a turn of the colon on the left, and betwixt the kidneys and the intestines there is a sympathy, which is apparent in the nephritic colic. The proper coat of the kidney is fine, dense, and firm, and closely surrounds the proper structure of the gland.

The figure of the kidney is an oval, a little incurvated, so as to form a sulcus or general concavity to one side, while the other takes a greater convexity. By the concave surface of the kidney, which is towards the spine and great vessels, the arteries and veins and ureter pass in by the sinus, round which the substance or glandular body of the kidney terminates abruptly.

The abdominal aorta and the vena cava lying close on the spine and near to each other, give off laterally the emulgent arteries and veins. The renal or emulgent artery comes from the side of the aorta betwixt the upper and the lower mesenteric arteries; that of the left kidney has its origin a little higher than the right: and the aorta being on the left and the cava towards the right side of the spine, the left emulgent artery is shorter than the vein; the artery longer than the vein on the right side. Again, the aorta being more closely attached to the spine, the emulgent vein lies rather above the artery.†

The vessels, and especially the arteries of the kidney, are very irregular in their number and form. Where they enter the body of the gland, they are accompanied with a capsule which continues with them to their final distribution. Sometimes a solitary vein is seen making its exit by the convex surface of the kidney.

We have had occasion to remark on the nerves of the kidneys and their connection with the coverings of the testicle, and to notice their effect in producing numbness of the thigh and retraction of the scrotum in inflammation of the gland, when stones lodge in the pelvis or ureter.

Upon the subject of the sensibility of the kidney, however, we must be aware that disease, inflammation, suppuration, nay, even total wasting of the kidney may take place without any indication from pain, and certainly without pain referable to the part itself.

The excretory duct of the kidney is called URETER: it leads from the kidney to the urinary bladder. When we trace it backwards into the kidney it is found to enter the sinus of the kidney. Here it is enlarged into a considerable sac, which is called the PELVIS of the kidney. This is a kind of reservoir, which, lying partly in the embrace of the solid and glandular substance of the kidney, sends up several prolongations like the fingers of a glove. These are called *infundibula*. They are, indeed, like funnels, for they expand to receive the papillæ of the kidney from which the urine distils.

* See a case, by Dr. Simmons in the Philosophical Transactions, vol. lxiv.

† The vessels of the kidney vary more than those of any other viscus. C. H. Meuder de urinæ excretione. Sandifort. Thes. viii.—Albinus. Acad. Annot. b. vii. c. 11.

It may be observed, however, that the term pelvis is taken from the greater dilatation of the ureter within the gland, which is seen in brutes; and that in man it is not so remarkable, the ureter branching with only a lesser degree of the sacculated form into three or four divisions, and these into the infundibula.*

The coats of the ureter are three in number; — a dense outer coat; a middle coat, apparently consisting of circular muscular fibres, though this has been denied; and a smooth inner coat (very improperly called villous), which secretes a mucus to defend it from the acrimony of the urine. The ureters do not run in a direct course to the bladder of urine: they are in some places irregularly dilated, as when they pass over the psoas muscle†; dropping deep into the pelvis, and getting betwixt the rectum and bladder, they open obliquely into the latter.‡ The use of the ureter is to conduct the urine which is incessantly secreted§ in the kidney to the urinary bladder, where it can be retained and discharged at a convenient time.

MINUTE STRUCTURE OF THE KIDNEY.

Let us now attend to the structure of the gland. The ancients, says Malpighi, contented themselves with the idea of a sieve, as conveying a knowledge of the manner in which the urine was drawn off by the kidney; that the fibres of its parenchymatous matter attracted the serum of the blood; that the fibrous matter was perforated with innumerable foramina; or that the whole was a congeries of canals through which the urine was strained and drawn off. Malpighi set himself to refute these vague opinions by the minute examination of the structure of the kidney; and he seems to have known almost all that we now know. Though we do not acquiesce in his opinions regarding the final and minute structure, he describes accurately every part of the gland.

In the first place, when we examine the outward appearance of the kidney of the fœtus, we observe that it is not, like that of the adult, smooth, and uniform, but tuberculated or lobulated; that it consists of

* In my Collection, specimens may be seen of the pelvis in the human kidney dilated, to contain several ounces.

† When the bladder is contracted in consequence of a stone, or when it is dilated by obstructions, as from stricture, the ureters become dilated to the size of small intestines. Specimens may be seen in the Collection.

‡ *Nuck* describes the ureters as being very irregular, and always contracted in three or four places. *Bartholin* thought he observed valves as the duct enters the bladder, and *Coschwitz* describes valves in their course.

§ When a fistula of the loins communicates with the kidney the urine flows uninterruptedly.

distinct parts, or glands united together. Again, when we examine the kidneys of other animals, we find in several instances that the full-grown animal retains this lobulated form. In short, it immediately strikes us, that the kidney is not a uniform mass of glandular matter, but that it most resembles those glands which they call conglomerate, and which consist of several compartments or distinct glands united together.*

A section of the kidney shows us these parts. First, we see towards the surface that which is called the cortical or glandular part. Secondly, striæ, converging towards the centre of the kidney, being what is called the tubular part of the kidney.† These tubuli are divided into fasciculi, taking a conical shape; and these converging unite at the apex; two or three of them united form a papilla. The papillæ are generally ten or twelve in number, or even more, in each kidney; their points are received into the extremity of the infundibula; they pour the urine into these tubes, which is collected in the pelvis or cavity leading to the ureters.

We shall now separate one of those compartments of the kidney, which correspond with the original lobulated form of the gland. This figure represents such a portion.

When we examine one of these papillæ in a lobulated kidney, we find that it is the centre of one of these subdivisions.‡

The papilla C is merely the continuation of the tubuli B; but it is that part which projects from the body of the kidney into the calyx or infundibulum; and although these divisions of the substance of the kidney are enumerated as three distinct parts, the cortical, tubular, and mamillary parts, they are properly only two, the cortical and tubular parts.

Some, however, have made a new distinction, by asserting that a vascular part is to be observed betwixt the cortical and tubular, or striated parts; but it is not the case; for although when we make a regular section of the whole gland, the mouths of some larger vessels may be observed betwixt the fasciculi of the urinary tubes, yet they are irregular ramifications tending to the outer cortical part, and not such as separate the tubular and cortical part from each other, nor so regular as to be considered as one of the subdivisions of the kidney.

* The figure represents the kidney of the fœtus, which is *lobulated*, and the *glandula renalis* seated upon it.

† Improperly medullary, sometimes STRIATA. Winslow (*traité du Basventre*) has these distinctions of the substance of the kidney:—1. Corticale; 2. Cannellé sillonné, ou tubuleuse; 3. Mammelonnée.

‡ A. A. Cortical substance; B. Tubular part; C. Papilla; D. Ducts.

OF THE CORTICAL PART.

The external and cortical part of the kidney is by all allowed to be the secreting, or, as they rather term it, the secerning part of the organ. It was this part which the older writers considered as in a more particular manner to consist of a peculiar fleshy substance, or parenchymatous matter. It is in this cortical matter that the glandular bodies described by Malpighi are supposed to be seated; they are called *corpora globosa*, or *rotunda*. They are to be seen very distinctly in many brutes; for example, in the horse's and cow's kidney. But he asserted these bodies to be also observable in the human kidney; to demonstrate which he injected a black liquid mixed with spirit of wine, by which the kidney becoming universally tinged, you may then see, he said, when you have torn off the coats of the kidney, small glands partaking of the colour of the arteries. These are the glands of the cortical part of the kidney, which Malpighi described as hanging upon the branches of the arteries like fruit upon the pendant branches, and round which the arteries and veins are ramified and convoluted, like delicate tendrils, so as to give them the dark colour which they have.

Into these bodies he supposed the urine to be secreted, and that from these bodies it was conveyed into the uriniferous ducts or tubular part of the kidney; but he acknowledges that the communication betwixt the ducts and glands is very obscure.

Ruysch and Vieussens held a very opposite opinion regarding the structure of the kidney.* Ruysch, by throwing his injections into the renal arteries, found that he filled the urinary tubes, the ducts of Bellini, and the pelvis itself. Hence he conjectured that the tubuli uriniferi, or excretory ducts of the kidney, were the continued branches of the renal artery, without the intervention of any glandular apparatus.†

Ruysch did not neglect the examination of the little bodies which are to be seen in the cortical substance. He did not, however, allow they were glands, but confidently asserted that they were merely the convoluted arteries which were formed into these contorted bundles before finally stretching out, and terminating in the straight urinary tubes.‡

When, after minute injection of the kidney, we make a section of its whole substance, we see vessels emerging from the more confused intricate vascularity of the cortical part, and running inward in striæ towards the papillæ: what we see there, are, in my conception, chiefly veins. And this I conclude, both from the result of injections, and from knowing that the veins are in general numerous surrounding the excretory ducts; besides, they retain the blood in them like the veins.

* Ruysch and Vieussens long contended for the claim of the discovery of the continuation of the arteries of the kidney into the urinary ducts. Ruysch at first acquiesced in the opinion of Malpighi, as we have said.

† Thes. Anat. ii. p. 31.

‡ In the epist. to Boerhaave, p. 77., we find Ruysch speaking much more modestly: "In rene humano rotunda corpuscula esse, fateor, sed sunt tam exilia, ut nihil possim definire de illis. Adeoque non licet magis dicere quod sint glandulæ, quam aliud quid."

These vessels running in straight lines, and converging towards the papillæ are not the tubuli uriniferi, but the blood-vessels accompanying them, the tubes themselves being transparent.

Yet I imagine it was by these vessels that Ruysch was deceived; for tracing them from the extreme arteries, and seeing them suddenly altered in their form and direction, and running towards the papillæ, he imagined them to be the excretory ducts continued from the extreme branches of the arteries.

Winslow supposes the corpuscles, which are seen in the cortical part of the kidney, to be the extremities of the cut tubuli, filled either with blood or with a coloured injection. But this they evidently are not; for by making the substance around them transparent, they are seen within the surface, and they are little grains, not the extremity of tubes, nor extended in lines.

Boerhaave, although he saw in the preparations of Ruysch the injection passed into the uriniferous tubes, yet in the main favoured the opinions of Malpighi; and having sometimes observed these tubes filled with injections, while at intervals they were transparent or pale, and contained only a watery fluid, he ventured to conclude that there was a double operation going forward in the kidney; that the pale watery urine was quickly drawn off by the continuous tubes; but that the urine of the other quality and higher colour was separated by a more perfect and slower secretion through the glandular bodies.

In the history of opinions, to Boerhaave succeeds Bertin, who writes a long and laboured paper in the Memoirs of the Academy of Sciences for 1744: upon the whole, he may be considered as endeavouring to prove by dissection what was rather an hypothesis with Boerhaave. Bertin describes glands in the substance of the kidney; but these he is careful to distinguish from the corpuscles of Malpighi, which he also conceives to be the extremities of vessels merely.

He observes, that there are to be seen serpentine vessels, such as Ruysch described*; which, arising at the circumference of the cortical substance, are reflected inward in a tortuous form, and which, at last, approaching the tubular part, terminate in straight tubes, or are continued into the tubuli uriniferi.

But betwixt the meshes of vessels which are described, and which terminate in the tubuli, there are beds of glands; which acervulæ of small glandular bodies are, as it were, laid in a tract from the circumference towards the centre, and appear to terminate or to be connected with the tubuli uriniferi as the arteries are.

M. Ferrein has opposed all these opinions in a paper in the Memoirs of the Academy of Sciences for 1749. He asserts that the body of the kidney is neither composed of glands nor a congeries of blood-vessels; that it is a peculiar substance, which when examined is found to consist of transparent vessels. These, he says, are wonderfully convoluted in the cortical part of the kidney, so as to resemble glands, and stretch in parallel lines towards the papillæ, where they form what is called the tubuli uriniferi. Amongst these transparent tubes the blood-vessels

* Mesches de M. Winslow, ou vassieaux spongieuses de Vieussens, ou tuyaux serpentins de Ruysch.

ramify to great minuteness, and accompany them where they are reflected directly inward to form the tubuli. Much ridicule, he observes, has been thrown upon the term parenchyma of the ancients; but notwithstanding, he affirms, that there is in all glands a substance dissimilar from the blood-vessels, a gelatinous-like matter, which consists of or contains these pellucid tubuli.

Tubular part.—The term here used is universally received; and all seem agreed that the striæ converging to the centre of the kidney, and taking a pyramidal shape, are the excretory ducts. We have seen that they were supposed by some anatomists to be formed by the continuation of the extreme branches of the arteries; but this opinion we shall venture to say arose from the appearance of the blood-vessels injected, which lie parallel and close to them. They are evidently transparent tubes, and probably the fibrous appearance of the whole pyramidal body formed by them is owing to the accompanying blood-vessels. These lesser ducts, as they approach the papillæ, terminate in larger ducts, which finally open into the ducts of Bellini at the point of the papillæ. The papillæ we have seen to be that part of the pyramidal body which projects into the calyces or infundibula, and from their point little drops may be perceived to form when they are compressed. This fluid comes from the ducts of Bellini.

I have detailed the several opinions regarding the structure of the kidney; and neither do I wish here to vamp up an opinion from the aggregate of these contradictory reports, nor have I been able to draw a decided conclusion from my own experience. I must however conclude, there yet remains much to be done in investigating the minute structure of the glandular viscera.*

OFFICE OF THE KIDNEYS.

The kidneys secrete the urine: but this drawing off of the fluid from the system is not the sole object of the secretion; the water conveys away certain matters in solution. As the urine contains more saline matter than any other secretion, we are led to suppose, that the kidney is of use to rid the system of these saline substances.

These principally consist of the muriatic salts, as the muriate of potash and soda; the phosphoric salts, as phosphate of soda, of lime, and ammonia; the phosphoric and lithic acids, with animal extractive matter, and a gelatinous or albuminous matter. In short, chymists have declared, that eleven substances are constantly present in the urine, and occasionally others, the product of morbid action; so that from the kidneys much, both of the solid and fluid composition of the frame, must be sent off in that circle of action, deposition, and absorption, by which both the structure of the frame and the qualities of the living body are preserved.

* Of the kidney, much in Morgagni, Adversar. Anatom. iii.

OF THE CAPSULÆ RENALES.*

The renal capsules are glandular bodies of a reddish yellow colour, one attached to each kidney. The gland is seated like a cap on the upper end of the kidney. It is of a form like an irregular crescent, and suited to the shape of that part of the kidney to which it is attached; at the same time that it has three acute edges, being something of a triangular form.—The upper edge has been called crista, while the lower edges have the name of lobes. It is in the fœtus and in childhood that the renal capsule is large and perfect; in the adult it has shrunk, and no longer bears the same relative size to the kidney. In the fœtus the renal capsule is as large as the kidney, and the capsules of each side are continued into each other, being stretched across the aorta and vena cava.†

The vessels sent to this body are somewhat irregular; they come from the renal or emulgent arteries and veins, from the cœliac artery or phrenic, or from the trunk of the aorta, and even from the lumbar arteries.

By separating the lobes of this body we find something like a cavity, which has been roundly asserted by some to be a regular ventricle; by others altogether denied. Finding a cavity, they supposed they must discover the excretory duct. Some conceive that it must be connected with the pelvis of the kidney; some, with the thoracic duct; some, with the testicle; but every thing relating to the use of this body has hitherto eluded research, and all is doubt and uncertain speculation.‡ For my own part, I conceive that this body is useful in the fœtus, by deriving the blood from the kidney, that gland not then having undertaken its proper office of secreting the urine.

* *Glandulæ atrabilaræ, renes succenturiatæ, glandulæ renales,* &c. See the marginal figure.

† For various authorities on the size and appearance of this body, see Morgagni, Epist. Anatom. xx.

‡ Morgagni, Adversar. An. iii. A. xxxii. 329. Valsalva is reduced to the necessity of quoting Scripture, and Morgagni is as much at a loss, Epist. Anat. xx., being obliged to join in the words of Eustachius: "iis relinquamus, qui anatomen accuratius exercent, inquirendum."—*Morgagni,* loc. cit.

THE

ANATOMY

OF THE

MALE PARTS OF GENERATION.

As there is no very accurate division betwixt the viscera of the abdomen and those of the pelvis; as the uterus and bladder, being viscera of the pelvis, rise into the belly when distended, and are in every respect like the abdominal viscera, many have altogether objected to a division of the viscera of the abdomen and pelvis: nevertheless, there appears to be good reason for this division of the subject. The functions of the parts are different; the manner of their connection is different, and their diseases have widely different effects.

We have seen that the pelvis consists of the sacrum, os coccygis, and ossa innominata, and that anatomists have distinguished the true and the false pelvis. The false pelvis is formed of the extended wings of the ossa ilii, and supports the viscera of the abdomen. The true pelvis consists of that cavity which is beneath the promontory of the sacrum and the linea innominata; it contains, in man, the rectum, the urinary bladder, the prostate gland, the vesiculæ seminales, and part of the urethra. In woman it contains the rectum, vagina, uterus, Fallopian tubes, ligaments of the uterus, and ovaria.

The manner in which the parts of the male pelvis are connected, and the anatomy of the urinary bladder, prostate gland, and urethra, will form the subject of the first section; while the anatomy of the parts connected in function with those of the pelvis, but seated without, will form the subject of the second.

OF THE PARTS WITHIN THE PELVIS.

We have seen that the abdominal viscera are involved in a common membrane; that this membrane is uniformly smooth; and that it has a secretion on its surface which bedews the whole, and allows the parts an easy shifting motion on each other. The parts in the pelvis must also have motion, but they are at the same time more intimately connected; a loose cellular membrane is the medium of adhesion here: the

parts are imbedded in cellular membrane, which is interwoven with muscular fibres towards the lower opening of the pelvis, and further braced by the levator ani and muscles of the perinæum. This gives to the whole due support; enabling them to resist the compression and action of the abdominal muscles, which they must receive in common with the higher viscera of the belly.

By turning to the plan of the peritonæum, we find that the division of the parts in the pelvis and abdomen is not well defined; but we see that the peritonæum is reflected from the pubes over the urinary bladder, and mounts again upon the rectum. The line of division, therefore, is the peritonæum; while we understand how the bladder, which belongs to the pelvis, being distended, carries the peritonæum before it, and rises into the abdomen.

OF THE BLADDER OF URINE.

The bladder of urine must be classed with the membranous or hollow viscera. It is a bag or receptacle into which the urine slowly distils through the ureters, that it may be expelled at convenient seasons. It is nearly of a regular oval form, when moderately distended, the ends being obtuse; but from its connections, and the pressure of surrounding parts, this regular extension is not allowed in the living body. When seen moderately distended, *in situ*, it rises somewhat pyramidal upwards; it is flat upon the os pubis on the fore part, and towards the back and lower part a portion may be seen somewhat sacculated, and below the level of the commencement of the urethra.

We describe the body, fundus, neck, and lateral parts. The fundus is the upper part; the neck is where the urethra commences, and where the prostate gland is attached; the lateral part is where, being distended, it stretches at its lower part to the sides of the pelvis.

On the fundus there is a ligamentous process, continued in a direction towards the umbilicus; this is the urachus. I would not give the name here, which is properly applicable to a tube peculiar to the fœtus of quadrupeds, were it not to add that sometimes, even in the adult human subject, there is an open tube, so that the urine passes out from the umbilicus.*

The bladder is situated higher in the boy than it is in the adult. In the fœtus it is almost entirely out of the pelvis, and reaches nearly to the umbilicus. At three years it is said to rise no more than three fingers' breadth above the os pubis; at twelve it is only about half an inch above the level of the bone; at eighteen it is said to be completely hidden behind the pubes.

When the bladder is empty, or contains only a moderate quantity of urine, it takes a triangular figure in the dead body, the base of which rests on the rectum, and the apex is attached to the back of the os pu-

* Fernelius, de Part. Morb. et Symtom., gives an example of a man who, having an obstruction at the neck of the bladder, passed his urine by the umbilicus. Wipfer gives a similar case of a man with calculus. These are quoted by Albinus, Annot. Acad., and also the Philos. Transactions, n. 323. See also Sandifort, Thes. vol. iii. p. 234—246. Haller, Elemen. Physiol. lib. xxvi. § ii.

bis; and when in dissection you look down into the pelvis, you find the back part of the bladder flat, and as it were stretched obliquely upon the os pubis.

Structure of the bladder. — Like the other hollow viscera, the bladder consists of several coats.

The peritonæal coat of the bladder does not surround the bladder, but only covers the fundus and back part. It is like, in every respect, to the peritonæal coat of the abdominal viscera; smooth without; and adhering to the inner coat by cellular membrane; which cellular membrane is, however, of a looser texture, and in greater quantity than under the peritonæal coat of the abdominal viscera. This peritonæal coat is no doubt of much service, as a division, in obstructing the course of inflammation arising from the diseases in the lower part of the pelvis, or from operations performed on the bladder, rectum, or perinæum; were it not for the loose peritonæum spreading over the cellular texture of the pelvis, we could neither be so bold nor so successful in our operations here. That portion of the peritonæum which covers the back part of the bladder, forms a particular transverse fold when the bladder is contracted. This fold surrounds the posterior half of the bladder, and its two extremities are stretched towards the side of the pelvis, so as to form a kind of lateral ligament.*

Though in the contracted or moderately distended state of the bladder, the peritonæum stretches from the back of the os pubis to the bladder, the distention of the bladder, in an immoderate degree, raises the peritonæum off from the pubes, so that the bladder can be struck with a trochar, or lithotomy performed above the pubes, by an incision directly into the bladder, without piercing the outer or peritonæal coat.

Towards the lower part, the bladder, as we have seen, is invested only by cellular membrane, which takes the place of the peritonæal coat of the fundus. This tissue is very loose, and permits the distention and contraction of the bladder, which looseness of texture is a matter of regret, when blood or urine is forced into this tissue.

Muscular coat.— The muscular coat of the bladder is very strong. Three strata of fibres are described by authors. They are so strong as to have been classed with the distinct muscles, and the whole coat has been called detrusor urinæ. Towards the lower part of the bladder the fibres are particularly strong, and formed into fasciculi, and are like a net of muscles inclosing the bladder.† These fasciculi acquire greater thickness and strength when the bladder is excited by opposition, as from stricture in the urethra.‡

Towards the fore and lower part of the bladder, the muscular fibres congregate into a sort of tendon, which goes off to the back of the os pubis, which we count to be the insertion of the tendon of the bladder, and certainly this hold, which the bladder has upon the os pubis, causes it, in its contraction, to be drawn to the back of the pubes.

We have an idea of the wonderful degree of contraction in the bladder, and indeed the extent of motion in the muscular fibre in general,

* See the description of the folds of the peritonæum.
† Morgagni Adversar. Anat. iii. Animad. xxxix.
‡ Some very remarkable examples of this may be seen in my Collection.

when we consider that the bladder extends so as to contain two pounds of urine, and contracts so as to force out the last drop from its cavity. When, however, the fibres are stretched too far, they lose the power of contraction, and often the young surgeon is deceived by what he conceives to be an incontinence of urine, while it is really an obstruction.

OF THE SPHINCTER OF THE BLADDER.

If we consider the double office of the urethra, and suppose that the seminal vessels and the ducts of the prostate gland open into the canal at a part posterior to the muscles which close the orifice of the bladder, we must be also forced to admit that there is some imperfection in the mechanism of these parts. For in that case, the fluids passing from those ducts would fall back into the bladder, and the orifices of the ducts would be exposed to the urine in the bladder, even when the bladder was closed. If this were really the case, it would be inconceivable how the contents of the *vesiculæ seminales* could be discharged forwards, or how the urine could be retained while the seminal discharge was made.

By such a train of reasoning I was led to look for the proper sphincter of the bladder behind the prostate. The importance of the knowledge of the complex apparatus of muscles, about the neck of the bladder, to the comprehension of the various causes of obstructed urine led me to review this part of the anatomy.

To exhibit the sphincter of the bladder, cut off all the appendages but the prostate gland; then make an incision into the fundus of the bladder and invert it. Begin the dissection by taking off the inner membrane of the bladder from around the orifice, or commencement of the urethra.

A set of fibres will be discovered on the lower half of the orifice, which, being carefully dissected, will be found to rise in a semicircular form round the urethra. These fibres make a band of about half an inch in breadth, particularly strong on the lower part of the opening; and, having mounted a little above the orifice on each side, they disperse a portion of their fibres in the substance of the bladder. A smaller and somewhat weaker set of fibres will be seen to complete their course, surrounding the orifice of the upper part; to these sphincter fibres a bridle is joined, which comes from the union of the muscles of the ureters.

Here, then, we have the muscle which closes the internal extremity of the urethra, the most posterior of all those muscles which embrace the urethra. It resembles the sphincters of the other hollow viscera; for example, those fibres which encircle the pyloric orifice of the stomach.

Third coat.—This third coat of the bladder anatomists have called the nervous and cellular coat; it consists of very extensile white lamellæ of cellular membrane. It gives distribution to a few vessels, and connects the muscular fibres and inner coat.

The internal coat of the bladder is very smooth on its general surface, and is bedewed with a sheathing mucus. When the bladder is

distended, no inequalities are to be observed; but when contracted, it falls into folds and rugæ. From an acrid state of the urine, from strangury, from calculus, the mucous discharge is increased, even so as to form a great proportion of the fluid evacuated from the bladder. No visible source of this mucus is to be observed on the inner surface of this membrane*; so that, probably, it is a general discharge from the surface. Indeed, it appears, that no follicles or cryptæ, discharging at particular points of the surface, could have the effect of bedewing and defending the whole surface from the acrimony of the urine.†

OF THE PROSTATE GLAND.

On the neck of the bladder, and surrounding an inch of the beginning of the urethra, there is a gland nearly of the size and figure of a chestnut. This body is called the prostate gland. In all anatomy, there is not a more important subject for the attention of the surgeon than this; he must consider the size, relation and connection, and diseases of the prostate gland.

This body is round at the base which is towards the bladder, pyramidal forward. It has a lateral division, forming it into two lobes; and the older anatomists speak of it as double. Mr. Hunter and Sir Everard Home have excited our attention to the posterior or third lobe of this gland, and have drawn the most important practical remarks from the observation of this part of the anatomy. While the prostate gland surrounds the beginning of the urethra, it rests on the rectum, and it is tied by a fascia, or ligament, to the back part of the os pubis. The urethra passes through it; not in the middle, but towards its upper surface; so that the gland is more prominent downward, and is distinctly felt by the point of the finger *in ano.* When the catheter is introduced, and the surgeon examines the state of parts by the rectum, he will first distinguish the curve of the staff, covered with the bulb of the urethra; behind this the catheter will feel more bare of parts, but still covered with a greater thickness of parts than one should expect from the description of the membranous part of the urethra; and behind this, again, he will feel the prominence of the prostate gland, not round, distinct, and accurately defined, but gradually lost both before and behind, among the surrounding cellular membrane and muscular fibres which involve it.

The texture of the gland is a compact spongy substance, and when cut has considerable resemblance to a scirrhous gland. From each lobe there are small follicles opening into the urethra, and from these the ducts may be injected.‡

It has been said, that there is really no division of this gland into lobes; but, perhaps, the best authority on this question is the morbid appearance. Now it happens sometimes that only one side of the gland is enlarged, which is a proof that there is some division betwixt the lobes. This unequal swelling of the gland distorts the urethra, and

* Winslow, however, describes the glands, and Heister and Haller describe the follicles, near the neck of the bladder, and round the insertion of the ureters.

† When the mucous secretion is diminished by a disease of the inner membrane of the bladder, the calculous concretion more readily forms on the surface.

‡ As first done by Monro.

gives it a direction very difficult to be followed by the catheter. In general, when equally swelled, the greater part of the gland being beneath the urethra, the urethra is raised up, so that the point of the catheter must be raised over the enlarged gland before we can pass it into the bladder.

On the lower part of the gland, and betwixt the bladder and the vesiculæ seminales, the third portion of the gland is situated, of which Morgagni gives this account. But if any addition is to be given, says he, to the description of the prostate gland, it is that roundish and smooth body like a gland, which often our very diligent dissector has shown in the public dissections. It lies prominent betwixt the bladder and seminal capsules where they are united. Upon our most accurate examination, we find this to be nothing more than a part of the prostate itself.* After this I can see no objection to calling this part of the prostate gland Lobus Morgagni. Morgagni likewise observes that it is not always to be found.

The prostate gland secretes a ropy mucus. It is probable that this mucus serves to sheathe the passages, and preserve them from the acrid urine. It certainly unites also to the seminal fluid, and is discharged with it.†

The diseases of this gland form a subject too important and extended to be even hinted at here.‡

Anterior to the prostate gland, and also close to the urethra, are seated the GLANDS OF COWPER. This gland is also for the purpose of discharging mucus into the urinary passage. It is seated in that angle formed by the abrupt termination of the bulb of the spongy body of the urethra, and consequently close to the membranous part of the canal. It has a long duct, which, running forward an inch in length, terminates in the surface of the urethra. To comprehend the anatomy of the male urethra, we must first notice the structure of the penis.

FURTHER EXAMINATION OF THE PARTS HITHERTO DESCRIBED AS SEATED AT THE NECK OF THE BLADDER—LA TRIGONE DE LA VESSIE—LA LUETTE—UVULA VESICÆ—CORPORA CARNOSA MORGAGNI—THIRD LOBE OF THE PROSTATE, ETC.

In the plates of De Graaff, there are represented certain folds, extending forward from the orifices of the ureters, where they terminate in the

* Vide Morgagni, Adversaria Anatomica, Animadversio xv. Prostatæ propago.

† Mr. Hunter says that the prostate gland undergoes changes, in its developement, corresponding with the functions of the testicle; that it shrinks and loses its natural texture in the castrated.

"The prostate gland is not common to all animals. It is wanting in the bull, buck, and most probably in all ruminating animals. In this class, the coats of the vesiculæ are much thicker and more glandular, than in those which have prostate glands. It is therefore natural to suppose that the vesiculæ answer nearly the same purposes as the prostate gland.

"The prostate gland, Cowper's glands, as well as the vesiculæ, are wanting in birds, in the amphibious animals, and those fish which have testicles, as all the ray kind."—*Animal Economy*, p. 44.

‡ For much of the anatomy and the morbid conditions of these parts, see SPECIMENS OF MORBID PARTS, *taken from the Collection of Windmill Street*. Folio. Longman and Co.

cavity of the bladder; and, at the lower part of the orifice of the bladder, there is a tubercle faintly indicated. The same appearance is represented by Bidloo. In Santorini also the natural appearance of these parts is accurately delineated. Morgagni expresses himself to this purpose :—"At the points where the ureters terminate in the bladder, there arises from each of them a thick, round, compact, fleshy body, which takes a direction towards the orifice of the bladder. These two bodies, having proceeded a little way, are united, and proceed forward, terminating in the Caput Gallinaceum."*

Santorini† gives the same description of these parts as Morgagni has delivered.

Lieutaud describes these bodies under the term, *La trigone de la vessie.* The learned Portal is incorrect in saying that Lieutaud was the first anatomist who has given their description.

Portal has thus described the *Trigone:* at the lower part, the internal tunic of the bladder adheres to a triangular body, of a cartilaginous hardness, and this body is always prominent in the cavity of the bladder, especially in old men. He proceeds to say, that, at the extremity of the triangle, backwards, the orifices of the ureters open; and, at their anterior extremity, there is an eminence, slightly protuberant, to which Lieutaud has given the name of *Luette.*

This account leads me again to refer to the plate of the excellent anatomist, Dominico Santorini. In his second table, the Luette and Trigone are accurately represented.

He has the following explanation on the letter I :—"Vesicæ urinæ osculum, cui prominulum corpus præfigitur, quod in affectis vesicæ sic prominet aliquando ut urinæ iter prorsus intercludat." This refers to the disease with which Mr. Hunter and Sir E. Home have made us familiar.

The expression of Santorini recalls us again to the remark of Portal. He says, "I have found in old men, who have suffered retention of urine, the *Trigone de la Vessie* so enlarged, especially its tubercle, in the form of an uvula (Luette), that the orifice of the bladder was shut by it."‡

Sabatier follows his countryman in his description of this part of the bladder, but adds, "The *Trigone* and *Luette* are the most sensible parts of the bladder; which is the cause why a stone lodging here produces extreme irritation, while, if it lodges in any other part of the cavity of the bladder, it causes little inconvenience." He adds, "The uvula (*Luette*), which terminates the anterior angle, is very subject to swell, and then it rises in the form of a round tumour, which fills the neck of the bladder, and opposes itself to the flow of urine."§

Dessault, speaking of the tumours which grow in the bladder, has this expression :—"Le sommet de ce viscère n'en est pas plus exempt que son bas-fond; mais ce sont particulièrement ceux qui croissent près de son col, et que quelques auteurs ont pris pour un gonflement de la luette vésicale, qui occasionnent la rétention d'urine."

This sentence, which betrays the imperfect knowledge which Dessault had of the disease, is followed by other unequivocal marks of uncon-

* See Morgagni, Adversaria, i. n. 9. Adversaria, iii. Animadver. xlii.

† In the Observationes Anatomicæ, cap. x. sec. xxi.

‡ Portal, Cours d'Anatomie Méd. t. v. p. 409.

§ See also Lieutaud, Hist. Anatomic. Medica. Tumores Vesicæ adnati.

firmed principles and practice; and the whole chapter stands in remarkable contrast with the publication of Sir E. Home, in this country.

In Haller's *Element. Physiolog.** we have a description, following that of Morgagni, under the title *Colliculi ab Ureteribus in Urethram producti.*

These authorities being discussed, we come now to the more modern observation of Mr. Hunter.

Mr. Hunter† has described a small portion of the prostate gland, which lies behind the very beginning of the urethra; and this he describes as subject to swell out like a point, in the cavity of the bladder, where it acts like a valve on the mouth of the urethra. This can be seen even when the swelling is not considerable, by looking upon the mouth of the urethra from the cavity of the bladder.

It is impossible to mistake this; the swelling he describes is the *Uvula Vesicæ*, or *Luette* of Lieutaud. The observations of Mr. Hunter then, go to inform us, that this tumour is of that part of the prostate gland which is below the urethra, and betwixt the lateral portions of the gland.

This discovery carries us back to the great anatomists in whose works we find the elements of all our present knowledge. Morgagni, we have seen, has very fully described the part of the prostate gland, which Mr. Hunter mentions, and which he discovered to be the seat of this dangerous malady.‡

In addition to the description of Morgagni we have the authority of Sabatier. "Sometimes," says he, "only that part of the prostate is diseased to which they have given the name of *Luette Vésicale.* I have seen several occasions," he continues, "in which the uvula forms a tumour, with a narrow peduncle: this moving with a stream of urine, closed the opening of the bladder."§

ANATOMY OF THE NECK OF THE BLADDER.

On dissecting up the inner coat of the bladder, there are seen too strong fleshy columns, which descend from the orifices of the ureters towards the orifice of the bladder: they unite and run towards the prostate gland.|| On the surface, towards the cavity of the bladder, they are denser by the union of the inner coat of the bladder, but they are fibrous, and this fibrous structure is made manifest by dissection from below. They are larger and firmer, but of the same colour and structure with the fleshy columns of the *Detrusor urinæ*. The variety which we find in their length according with the degree of contraction of the bladder, proves their muscularity. Whatever excites the action of the bladder increases the size of these muscles in a remarkable degree; and they always acquire a great increase of power and size when the muscular coat of the bladder becomes more distinct and powerful. In some of my specimens of diseased bladder, I find the cause of this to be stone in the bladder; in others, an ulcer; in many, stricture; but always irri-

* T. v. p. 328.
† P. 170.
‡ Morgagni, Adversaria Anat. iv. Animad. xv.
§ Med. Operat. t. ii. p. 72.
|| See the Gulstonian Lectures by Wm. Rutty, M. D. Treatise on the Urinary Passages, and a Description of their Power and Uses.

tation and the necessity of continual action of the bladder are attended with an enlargement of the muscles of the ureters.

When contracted, the course of these columns is distinguishable all the way from the mouths of the ureters to the beginning of the urethra; and there, at their union, they heave up the inner coat of the bladder, producing the appearance of a tubercle at the lower part of the orifice of the bladder.*

It is still the form of the inner coat which makes these fleshy columns appear to terminate forward in the caput gallinaceum, which they do not; they only take a firmer insertion. Where these columns unite they are most fleshy, and their fibres are most intricate; then, directing their course towards the lower and backmost part of the prostate, they degenerate into tendon, and are inserted into the portion called the third lobe of the prostate.

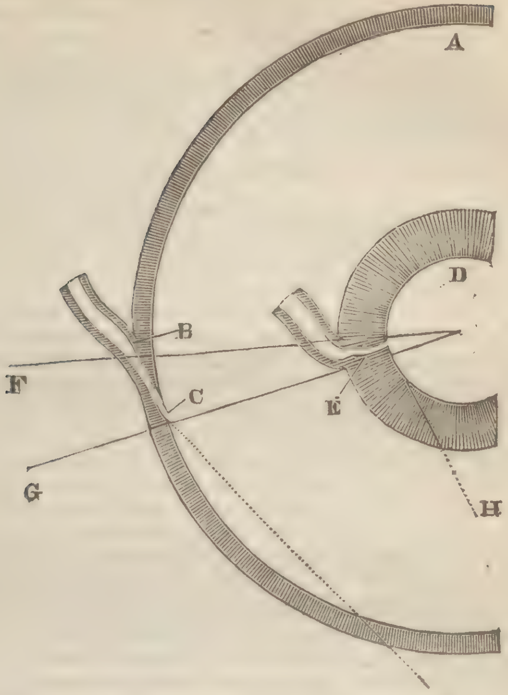
Although I have described the course of these muscles as proceeding from the back part forward, because it better corresponds with the first view we have of them, yet, I believe, it is more correct to consider their connection with the prostate gland as the fixed point, and their connection with the extremities of the ureters as their insertion.

Use.—The use of these muscles is, to assist in the contraction of the bladder, and at the same time to close and support the mouths of the ureters. The surface of the bladder, where it covers their union on the inside, is endowed with an exquisite sensibility, which is a provision of nature for their ready and instantaneous action on the stimulus to pass the urine. It is here that is seated that sensibility which produces the natural call to pass urine, and here also is the seat of diseased irritations.

It will be observed, that the orifices of the ureters are not closed by the contraction of the muscular fibres around them. They are defended against the return of the urine by the obliquity of their passage through the coats of the bladder. It is well known that the extremity of the ureters enter through the coats of the bladder obliquely; and that, in consequence of this, there is a valvular action in the coats of the bladder, which prevents the regurgitation of the urine into the ducts of the kidney.

But if we look to the adjoining diagram, and consider the subject, we shall find, that in proportion as the bladder contracts, this obliquity must be diminished. And further, if we reflect that the coat, which contracts, is on the outside of the oblique passage of the ureter, we shall conclude that without some counteracting power on the inside of the bladder to draw down the orifice of the ureter, the obliquity of the passage would be lost. These muscles, which I have now described, guard the orifices of the ureters by preserving the obliquity of the passage, and by pulling down the extremities of the ureters according to the degree of the contraction of the bladder generally.

* It is this appearance presented by the muscles in a state of contraction, which has led so many of our best authorities to confound it with the disease of the third lobe of the prostate gland.



EXPLANATION OF THE DIAGRAM.

Let A represent the circle of the dilated bladder: B, the ureter or duct of the kidney entering the coats of the bladder: C, the extremity of the duct opening on the inside of the bladder: B, C, mark the oblique course of the ureter through the coats of the bladder. Let D represent the contracted bladder, thickened at the same time by its contraction: E, the ureter passing through the coats.

The lines F, G, drawn from the centre of the circle, will intersect corresponding portions of both circles, and demonstrate how the oblique passage of the ureter, through the coats of the dilated bladder, becomes more direct in the contracted bladder.

The muscles described act in the direction of the lines H, H, and their operation is to draw down the orifice of the ureter C, in proportion as the bladder contracts, by which means the obliquity of the passage is preserved.

The membrane, which covers these muscles, is the seat of that sense which calls the muscular coat of the bladder into action. Of this we may be sensible in passing the bougie, and still more in passing the urethra sound. As the instrument is passed down the urethra, there is a sickening sensation; as it passes the caput gallinaceum, the nature of the pain is changed; and, lastly, in passing it over the surface of the triangular elevation, produced by these muscles, there is experienced the familiar sensation of the call to pass urine. If it were doubted that here, in a particular manner, is seated that sensibility which calls the bladder into action, the effect of a stone falling upon the part is sufficient proof.

When a patient has a stone in the bladder, there is pain and excitement while it rests in this place, and relief when it lodges elsewhere. The reason why this part is possessed of such sensibility I apprehend to be, that the muscles of the ureters may, as it were, be the first alarmed, in order to guard the mouth of the ureters, and preserve their obliquity during the action of the bladder.

ACTION IN DISEASE.

When the sensibility in the seat of these muscles is increased by disease, and the increased sensibility is accompanied with a continual action of the muscles, the prostate gland must suffer unusual excitement. The natural prominence formed by the muscles being directly over the third lobe of the prostate, and their chief attachment being also to this third lobe, we may perceive how it happens that this part is sometimes enlarged without the body of the prostate gland partaking much in the disease. When there is an unusual *nisus* of the bladder, these muscles are the seat of it; and as their united extremities are attached to the lower and middle portion of the prostate gland, they must, I think, promote the growth of this portion in a direction towards the cavity of the bladder. This will produce the true *uvula vesicæ*, the pendulous tumour in the neck of the bladder resembling the uvula of the palate. This tumour hangs into the cavity of the bladder, and falls like a valve upon the orifice of the bladder, proving a most troublesome and dangerous obstruction to the urine.

But whilst I state this as an opinion, drawn from the consideration of the parts in their natural state, I must also submit the naked facts. I have, in my Collection, two specimens of the disease of the third lobe of the prostate, where these muscles are remarkably strong. I have, on the other hand, some specimens of diseased bladder, where the muscles of the ureters are enlarged; and only in one of these is there a beginning enlargement of the middle lobe of the prostate gland.

I have many specimens of bone distorted by the action of the muscles; and many, where, at the attachments of the tendons, the bones are drawn out into spines and tubercles. We may say, such is the effect of the muscles; but though the growth of such spines or tubercles be the effect of the action of the muscles directly, yet these spines will not be formed unless when the bones are at the same time suffering from disease. So, in considering the action of the muscles of the ureters, as influencing the growth of the prostate in a particular direction, I do not imagine that the muscles will do this merely by their mechanical effect. There must be also a disposition to disease in the prostate; and if disease be not present, the irritation of the bladder will continue even till the death of the patient, without affecting the growth of the gland.

On the extremities of the ureters, in the diseased action of the bladder, the contraction of these muscles is converted from a salutary influence to one which aggravates disease. They still close the mouths of the ureters during the action of the bladder; and the action continuing, they cause an accumulation in the ureters and pelvis of the kidney, and influence the kidney itself, thus increasing the extent of the local disorder, and, consequently, its influence on the constitution.

Such consequences as arise from the irritation and action of these muscles are to be relieved by removing the cause, by assuaging the sensibility of the surface of the tubercle, and by drawing off the urine. When we know that this spot on the lower part of the orifice of the bladder is the seat of that irritability which is so distressing, we see that it is practicable to effect it by the use of the bougie. By the introduction of the catheter, the urine is let off without hinderance from the valve, the distressing excitement of the muscles is not perpetuated, and the prostate subsides from its irritation.

This practice, though a direct deduction from the examination I have made, is no more than the advice given to us by the best authors.

Thus we see that a small tubercle was painted by De Graaff, and described by others, but the nature and origin of the tubercle was misconceived. Anatomists were calling it *uvula vesicæ*, as if that natural prominence was the same with the *tumour* of this part of the bladder. We find that the disease called *uvula vesicæ* is no other than that occasioned by the enlargement of the third lobe of the prostate gland. To Mr. Hunter and Sir E. Home we are indebted for a full knowledge of the nature of this disease. It has been objected to Sir E. Home, that he is in vain making that important, which the great anatomists of all ages have failed to discover, or have neglected to notice. I have shown that the third lobe of the prostate was known to Morgagni, and that it was a subject of discussion in his day. We have sufficient evidence (even on this very subject) of the difference of a fact being noticed in the elaborate works of Morgagni, and of its being familiarly and practically known to surgeons. The third lobe of the prostate was quite forgotten; the consequence was that we were ignorant of the nature of the most fatal disease of the bladder. It would be disingenuously reserving the circumstance which drew me to attend to this subject, were I to omit the mention of the late work of Sir E. Home, or rather his original paper on the anatomy of the prostate gland. I acknowledge both the merit and the necessity of what he has written; for the observation of Morgagni and the hint of Sabatier were forgotten both here and in France, until the subject was distinctly and practically brought forward by Sir E. Home. Even the latest French author, Richerand*, still speaks of the enlargement of the anterior angle of the "*trigone vesicale*," and the growth of *fungosities* near the neck of the bladder, obstructing the course of the urine.

It still remained to be explained, why the small part of the prostate gland, the third lobe of Sir E. Home, should be so frequently enlarged, without the affection of the body generally being apparent, or why this part should enlarge more rapidly than the rest of the gland. It was in the prosecution of this enquiry, that I discovered the muscles of the ureters; and after ascertaining their nature, I saw through the obscurities of authors, in treating of the diseases of this part of the bladder; so that in speaking of the enlargement of the anterior extremity of a natural tubercle, they were deceived; and that, in treating of the *uvula*, they were describing the diseased prostate gland.

* Nosographie Chirurgicale, 2d ed. p. 458.

OF THE PENIS, URETHRA, AND TESTES.

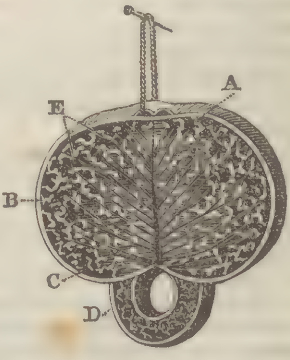
STRUCTURE OF THE PENIS.

THE penis consists of a spongy substance, admitting venous blood, and supported by a very firm elastic covering which restrains the over-distention, and gives the form. There are properly three spongy bodies. Two of these bodies are called the CORPORA CAVERNOSA PENIS; they form the body of the penis: the other is the CORPUS SPONGIOSUM URETHRÆ, a vesicular and spongy substance, which surrounds the whole length of the urethra, and expands into the bulb of the urethra in the perinæum, and into the glans on the point of the penis.

CORPORA CAVERNOSA.—The body of the penis consists of two tubes formed of a very strong sheath. This sheath has a great degree of elasticity; but at its utmost extension powerfully resists the farther distention with blood. These tubes are united in the greater part of the length of the penis, or rather they are parted only by an imperfect partition. Within them is a curious tissue which forms a cellular texture; into this texture the arteries pour their blood so as to occasion erection. The posterior extremities of these cavernous tubes are called CRURA PENIS: they separate in the perinæum, and each of them takes hold on the ramus of the os pubis. Forward, these cavernous bodies or tubes terminate in rounded points under the glans penis.

This internal tissue consists of cells connected with each other, and having a free communication through the whole extent of the penis. They are interposed betwixt the extremities of the arteries and veins, or probably while the arteries have communication, and open into the extremities of the veins, in the common way: they have such connections with this cellular structure, that in accelerated or excited action they pour their blood into them; yet in such a manner, that the blood circulates in the penis during erection as at other times, and the blood in the cavernous body is not stagnant.*

CORPUS SPONGIOSUM URETHRÆ.—Attached to the cavernous body of the penis there is a spongy body similar in structure: through this cellular or cavernous texture the canal for the urine, called urethra, takes its course, which gives rise to the name spongy body of the urethra, or *corpus spongiosum urethræ.*



The spongy body extends the whole length of the penis; and where it extends backwards into the perinæum, betwixt the crura of the penis, it is enlarged into a round head, which is called the *bulbous part*:—it is upon this, and on about an inch and a half

* The figure represents a section of the distended and dried Penis. A. Theca or sheath of the Penis. B. Corpus Cavernosum. C. Septum Pectiniforme. D. Corpus Cavernosum Minus, or spongiosum Urethræ. E. the lesser Septa of the Corpus Cavernosum.

of the lower part of the spongy body, that the ejaculator seminis or accelerator urinæ acts; and, as within this enlargement of the spongy body which surrounds the urethra there is a dilatation of the tube of the urethra itself, the use of the muscle is evident. It contracts upon this sinus of the urethra when distended with the discharge of the vesiculæ, the prostate gland, and testicle.

Forward, at the extremity of the penis, the spongy body is enlarged into the glans; thus forming the bulbous head of the penis which crowns the conical extremities of the cavernous body.

The spongy substance which we have described, admitting the blood freely into its cells, suffers erection at the same time with the body of the penis; and as the blood of the glans has free connection with the blood of the bulb seated in the urethra, we may perceive that the action of the ejaculator seminis upon the back part of the spongy body must affect the whole extent of that body and the glans also. The excitement of the glans gives the action to the accelerator or ejaculator muscle: the action of this muscle compresses the bulb, and in consequence the whole spongy body to the extremity of the glans is made turgid, and thereby diminishes the diameter of the urethra, adapting it to the emission of semen. Sir Everard Home, I observe, supposes "that an action takes place in the membrane of the urethra, to reduce the size of the canal, and fit it for throwing out the semen with the necessary velocity." I imagine, the action of the accelerator, and the state of distention of the spongy body resulting from it, will have this effect.

The obtuse glans spread upon the extremities of the cavernous bodies of the penis has no communication with them. We observe a posterior circular margin on the glans; this is the *corona glandis*, and behind this there is a depression called the cervix. About the corona and cervix there are many little glandular bodies.*

The PRÆPUTIUM is a loose prolongation of the integuments of the penis, which hangs over and defends the delicate and sensible surface of the glans. Its inner surface is continued from the common integuments; this is again reflected over the glans. Upon the lower side, and just behind the opening of the urethra, the præputium is tied in a particular manner to the surface of the glans. This connection limits the motion of the præputium, and is called FRÆNUM PRÆPUTII.

The whole integuments of the penis are of the same cellular structure with those of the rest of the body: they are particularly loose and distensible, and unincumbered with fat. We may see them in emphysema and in œdema monstrously distended.

OF THE URETHRA.

The urethra is the canal for emptying the bladder. It extends from the neck of the bladder to the extremity of the penis. It is formed of the continuation of the inner and third coat of the bladder; which last forms a reticular membrane, uniting the inner membrane to the spongy body. It is, however, supported through all its length, near the blad-

* Glandulæ odoriferæ of Tyson. See Morgagni Adversar. iv. Animad. xii. et sequent. *de Tuberculis Coronæ Penis.*

der, by passing through the prostate gland and sphincter fibres; further forward than this, where it passes from the prostate to the beginning of the spongy body of the urethra, it is invested and supported by firm ligamentous membranes and muscles; and in all the length of the penis it is included in the spongy body, which extends from the bulb to the glans. It cannot be described as a cylindrical canal, for it is closed unless distended with urine, and admits of very unequal distention. It begins large at the neck of the bladder; where, immersed in the prostate gland, it forms a little sinus; it is contracted again in a remarkable degree behind the bulb; it dilates into the SINUS of the URETHRA within the bulbous enlargement of the spongy body: it is gradually diminished forward; and it may be considered as cylindrical or equal in its diameter from this part forward to the point of the glans, where it is much contracted. There is still another sinus or dilatation of the canal described, the *fossa navicularis*, where the urethra is surrounded by the glans.*

The canal of the urethra is bedewed with mucus. The sources of this mucus are here particularly apparent; bristles to the amount of seventy may be admitted in the mouths of the little ducts. Besides the general surface and the glands which I have described, there are large lacunæ observable; into which mucus is secreted, and from which, as from receptacles, it is pressed out as the urine flows.† The inner membrane of the urethra is very delicate, and, when torn by the catheter, or by violent chordee, or opened by the caustic, bleeds profusely.

The internal membranes of the bladder and urethra are particularly sensible; drawing after them, when excited, not only the action of all the muscles in the lower part of the pelvis, but having sympathies in a particular manner with the testicle, stomach, and bowels, and with the whole system. The more curious and important effect of the injury of the urethra is the paroxysm of fever which it induces. Observing the regular occurrence of an intermitting fever in cases of fistula in the perinæum, we should imagine it to be the effect of the extravasation of the urine in the cellular membrane, and the effect of general irritation; until it is observed that the simple stricture produces that effect, and that a touch of the caustic brings on a violent paroxysm.

When the reticular membrane is inflamed, of course it loses its elasticity, and gives pain in erection. Sometimes the inflammation, being continued to the spongy body surrounding the urethra, makes it unequal in its capacity of distention to the cavernous bodies of the penis, and sometimes their cells are united by adhesion in the worst cases of chordee.

I cannot imagine, with some, that the urethra is muscular; *first*, be-

* Haller Com. lib. xxvii. sect. 1. § xxx. Sir E. Home on Strictures. Observ. de partibus genitalibus sexus potioris Sandif. Thes. VIII. p. 71.

† These are the *Canaliculi Morgagni*, Advers. Anat.—De gladulis urethræ, vide Morgagni Adversar. iv. An. vii. et sequent. There is much controversy and much confusion regarding the glands of the urethra, viz. *Prostatæ minores; glandulæ Cowperianæ; glandulæ Littreanæ, &c.* The reason of which I believe to be that the *lacunæ* do not appear glandular unless when they have suffered by inflammation: there is no round smooth body attached to them, unless their secretions have been increased, and the cellular membrane and vessels are condensed around the lacunæ.

cause I see no end it could serve in the economy; *secondly*, because there is no proof in support of the opinion; *thirdly*, because it is surrounded with strong fibres and a spongy body, which conjointly seem calculated for every purpose of the economy, and likely to account for every symptom which might be mistaken for spasmodic action in the canal itself. The idea of muscularity is derived from the symptoms of stricture and the irritability of the canal.*

The urethra is very elastic; not only allowing a very large bougie to be passed, and closing upon a thread, but it still more remarkably admits of elongation than of distention in the width of the canal. It is surrounded, as we have seen, with a spongy body and the cellular coat which is betwixt the delicate lining membrane of the urethra, and the spongy body partakes of the structure of both, and is very elastic. But when an inflammation attacks the canal, this cellular membrane is its principal seat. The point affected loses its elasticity; no longer stretches with the penis and urethra, but consolidates, or forms a strong membranous filament. To suppose this stricture to have been formed by the muscular contraction, in the diameter of the canal, would be to allow the partial action of one or two fibres, (for the stricture is like that which would be produced by the tying of a packthread round the canal, being a narrow circular ridge,) which is very unlikely. Sometimes, however, the stricture is only on one side of the canal, which, allowing it to be formed by inflammation, is very likely to happen: but, in consequence of the muscular action, cannot easily be supposed to take place, since the drawing of the muscular fibres would equally affect the whole circle.

As to the effect of heat and cold on an obstruction, it may be explained easily, without the supposition of muscular contraction: for as we know that the spongy bodies, and of course the whole canal, relax and elongate in warmth, as they are shrunk up and contracted in cold, like the skin of the body in general, without implying muscular contraction: so we see how this state would affect a stricture;—that, when the penis and the urethra were shrunk, the effect of the stricture would be increased, and the patient could pass his urine only when the parts were relaxed, by sitting in a warm room, or by the use of the bath.

But when surgeons speak of spasms of the urethra, they seem to forget the action of the surrounding muscles. Thus acrid and stimulating urine, or an irritable state of the urethra, will be followed by a small stream of urine; or, perhaps, a temporary obstruction is the consequence: but why should we suppose that the membrane of the urethra, which has no appearance of muscularity, causes this effect, when it is probably produced by the sphincter muscles, the fibres which surround the membranous part of the urethra, the levator ani, and, above all, by the accelerator urinæ, a muscular sheath of fibres surrounding three or four inches of the canal. Round the membranous part of the urethra, and behind the bulb, there is much interlacing of muscular

* Morgagni describes the membrane of the urethra as double, having vessels betwixt its laminæ. These are the veins described by Dr. Barclay. Observ. Anat. p. 1. tab. iv. J. C. Brums. Sand. Thes. VIII., describes two laminæ, one of which he considers to be the continuation of the muscular coat of the bladder. See a paper of Mr. Shaw's in the Medic. Chirurg. Trans.

fibres; and the levator ani, splitting, embraces it. Round the sinus of the urethra, and the bulb which covers it, is the accelerator urinæ, more properly the ejaculator seminis. In short, here is a whole class of muscles which sympathise with the state of the urethra; and these muscles, disordered in their action when the canal is inflamed, give occasion to those contractions which are attributed to the membrane of the urethra itself.

OF THE TESTES.

The TESTICLE might be considered as more naturally connected with the abdominal viscera than with those of the pelvis, as its original seat is on the loins amongst the abdominal viscera, and as it receives its coats from the peritonæum, its vessels from the abdominal vessels, and its nerves from the plexus belonging to the vital parts.

The testicles are two glandular bodies, which secrete the semen: they are seated in the scrotum, and are covered and protected by several coats; they receive their vessels from the aorta and cava, or the emulgent vessels; their excretory ducts run up into the belly, and terminate in the urethra near the neck of the bladder.

The SCROTUM, in which the testicles are lodged, is a continuation of the common integuments: its cellular membrane is particularly lax and free from fat, and the water of anasarca is extremely apt to fall down into it, so as sometimes to distend the scrotum to a transparent bag of enormous size; and not unfrequently the cellular texture here has been blown up to counterfeit rupture and other diseases.

OF THE DARTOS.— The cellular substance of the scrotum is peculiar in its appearance, being red and fibrous. It has been considered as a muscle, and called DARTOS*, although this is denied by many. Its action is to support and brace the scrotum; and in bad health†, and in old age, it is so much relaxed as to allow the testicles to hang upon the cords. But besides the simple corrugation and relaxation, the scrotum has a motion like the vermicular motion of the intestines, obliquely and irregularly from side to side. Its contraction has a relation to the healthy secretion of the gland within; and when for some obstinate disease of the body of the testicle blisters are applied to the scrotum, we may see this muscle, in great activity, rolling round the testicles. The straight fibres of the *cremaster* muscle could not, I imagine, perform this revolving motion, and therefore I conclude that the dartos is a muscle, on a testimony better than is to be had from dissection.

There may be traced from the web of cellular membrane which covers the abdominal muscle a kind of imperfect expansion descending upon the testicles. This becomes very strong when hernia has taken place at the ring.‡

SEPTUM.—Upon the surface of the scrotum, directly in the middle, there is a line passing from the lower part of the penis to the anus—the RAPHA. This line makes a division in the scrotum, a partition, or sep-

* Δαρτος, Veterum.

† Nurses attend to the state of the scrotum in children.

‡ *Mouchart* de Hern. p. 14. tab. ii. *Garengeot. Haller.* Monro.—I have during operation separated this into three laminæ.

tum, which divides the scrotum into two distinct cellular beds for the testicles.

Coats of the testicle.—The *cremaster* muscle is expanded over the proper coats of the testicle. The origin of this muscle (as we have seen in Vol. I.) is from the internal oblique muscle of the abdomen: it passes through the hole of the external oblique muscle, called the *ring*, and descends over the vessels to the testicle, constituting a part of the cord, and finally spreading its fibres over the *tunica vaginalis testis*. Its use is to suspend and draw up the body of the testicle.

Under the fibres of the muscle we may discover a process of cellular membrane which comes down from the cellular membrane behind the peritonæum, and has been usually called a process of the peritonæum, even before the coats of the testicle were discovered to be originally formed by that membrane.

Besides the involving scrotum, each testicle has distinct coats. The tunica vaginalis, according to our best authors, covers the testicle loosely; that is, without adhering to its general surface: but the albuginea is in close union with it, and is the immediate coat of the testicle. The inner surface of the vaginal coat is perfectly smooth, and an exudation is poured out from it, as from the peritonæum within the belly. The outer surface of the tunica albuginea is also smooth and firm, and white, whence its name; but, on its inner surface, like the peritonæum, which covers the intestine, and adheres to the muscular coat, it adheres to the proper substance of the testicle. These investing coats are in some respects dissimilar, yet in general much alike, one being continued into the other, and both prolongations of the peritonæum. The outer membrane, the tunica vaginalis, is a protection to the testicle, by gliding easily on the inner coat; and aided by the mobility of the cellular membrane of the dartos, it preserves the testicles from bruises and strokes, to which it would be exposed if it were more firmly attached. The inner tunic, or albuginea, gives strength and firmness to the substance of the testicle. Betwixt these coats is the fluid collected which forms the hydrocele. They also contain the congenital hernia; but the common hernia is without both coats of the testicle. To understand the anatomy of this part thoroughly, we must attend to the descent of the testicle, and to the manner in which these coats are formed.

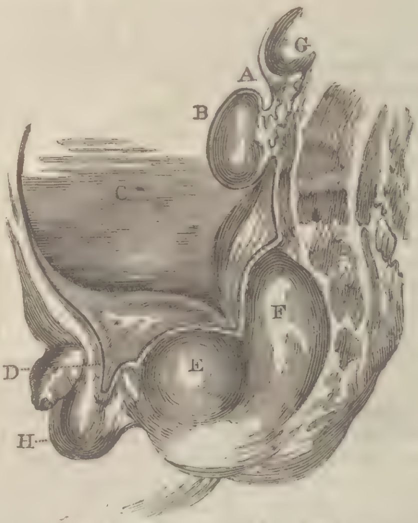
OF THE DESCENT OF THE TESTICLE.*

In the fœtus, some months before birth, the testicles are lodged in the belly, and are, in every respect, like the abdominal viscera. They are seated on the fore part of the psoæ muscles, by the side of the rectum. They are covered and invested by the peritonæum; for as we have explained how the solid viscera and the intestines are behind the peritonæum, so will it be understood how the testicles, lying on the loins, are

* Dr. W. Hunter discovered the situation of the testes in the abdomen of the fœtus, and suggested this to his brother as a subject of investigation. Mr. J. Hunter distinctly described the anatomy of the descent of the testicle, and explained the formation of its coats. See his *Animal Economy*. In reading *Kerckringius* one is apt to believe he understood the nature of the descent of the testicle. Spicilegium Anatomicum, p. 35.

behind the peritonæum; that is to say, the glandular substance of the testicle is invested by a coat, and that coat is the peritonæum, which, after covering the body of the testicle, is reflected upon the loins; as the coats of the liver, for example, are to be traced from its surface to the diaphragm. No words, however, can well explain this subject, and it will be better understood by these plans.

FIRST PLAN OF THE TESTICLE.



We see that the body of the testicle A is seated on the loins, that it is attached by vessels, and invested by the peritonæum. This surrounding of the body of the testicle by the peritonæum forms that coat which is in union with its substance, and which descends with it into the scrotum, and forms the tunica albuginea.

The figure and presenting surfaces of the testicle, while within the belly, are the same which we find after it has descended into the scrotum. It stands edgeways forward, and the epididymis lies along the outside of the posterior edge of the testes. We see that it is attached, by the peritonæum being reflected off from its back part, and we can trace the peritonæum upwards over the kidney G, and downward over the rectum F, and bladder of urine E.

We may also observe a process of the peritonæum which has passed through the abdominal ring, and which in this plan is marked D. Now it may easily be understood, that the testicle A, gradually shifting its place from its connections in the loins, drops down into this sheath D. It will also be easily understood how the testicle, covered with its first coat B (viz. the tunica albuginea), when it has fallen into D, is invested by this sac of the peritonæum, and that this last covering will come to be the tunica vaginalis. The tunica vaginalis is so called, because it covers the testicle like a sheath; that is, it does not universally adhere to the surface of the albuginea, as that coat does to the body of the testicle.

Understanding the nature of the peritonæum, we may learn the meaning of this looseness of the outer coat of the testicle. By turning to the introductory section of the abdominal muscles, we find, that the inside of the sac of the peritonæum is smooth, and forms no adhesion, whilst the outer surface, being in contact with the substance of the several viscera,

has a connection with them by a common cellular membrane. Now, as the inside of the peritonæum does not adhere, as the surface of the peritonæum (which in this first plan is towards C), is smooth, and has no tendency to unite with the surface of the viscera; so neither has the surface of the peritonæum at D the tendency to unite with the peritonæum (or the surface of the albuginea) at B, when it descends to meet it; consequently the coat of the intestines may be represented in this second plan, thus:—

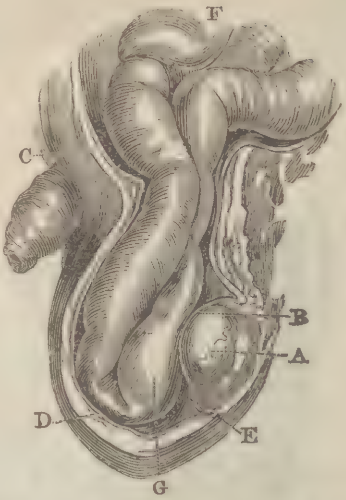
SECOND AND THIRD PLANS OF THE TESTICLE.

In the first plan, we had the situation of the testicle in the fœtus represented. In the second plan, we have the middle stage of the descent represented; and in the third, we have the full descent. In the second figure, A is the body of the testicle, B is the first peritonæal covering, or tunica albuginea, which can be easily traced, reflected off from the loins at C; again, D is the portion of the peritonæum, which, having descended before the testicle, is presently, when the testicle has fully descended, to become the second, or vaginal coat of the testicle; F is the continuation of the peritonæum upon the inside of the abdominal muscles.

In the third figure of this series, we find the testicle A has descended into the scrotum; that it has one coat covering it, which we recognise to be the same with B, in the first figure, and that the peritonæum in this third plate at B can be traced to C, the peritonæum within the belly.

Now, supposing this to be the state of the testicle immediately after it has descended, we see that there is still a communication betwixt the cavity of the tunica vaginalis D, and the cavity of the peritonæum E. F is the kidney covered by the peritonæum, and nearly in the situation in which the testicle was before its descent.

FOURTH PLAN OF THE TESTICLE.



From this fourth plan of the the testicle, we may learn the nature of the congenital hernia. It is a hernia produced by the intestine slipping down from the communication betwixt the general cavity of the peritonæum and the cavity of the tunica vaginalis, or in consequence of an adhesion betwixt the testicle and a portion of the gut, which of course causes the gut to follow the testicle, and prevents the communication betwixt the belly and the cavity of the tunica vaginalis from being shut. Thus in fig. 4. A is the testicle as seen in plan 3.; B, the tunica albuginea; C, the peritonæum within the belly; D, the tunica vaginalis, which we can trace from C, and which is distended and separated from the surface of the testicle (*i. e.* of the albuginea), by a portion of the gut, which has descended through the ring; E, the point of reflection; F, the intestines within the belly; G, the intestine which has fallen into the tunica vaginalis, and is in contact with the testicle; that is, in contact with the tunica vaginalis, which is in close union with the gland, and is considered as its surface.

We have explained the change which takes place in the situation of the testicle, as it relates to the peritonæum; but how this change is brought about, it is very difficult to understand. It is not a sudden pulling down of the testicle, but a very gradual process, continuing for months: it is not the effect of gravitation, for the fœtus may be in every variety of posture while in the womb, and generally the head presents. It is not respiration. Is it, then, the effect of the action of the cremaster muscle? or must we refer it to a law such as that which controls and directs the growth of parts?

When the parts in a fœtus before the descent of the testicle are dissected, there is found a ligamentous, or cellular cord, mingled with the fibres of the cremaster muscle, and which takes its origin from the groin, is reflected into the abdominal ring, and stretches up to the body of the testicle. This body is called ligament, or gubernaculum, and to the agency of this bundle of fibres is the descent of the testicle attributed. There are, however, objections to this. If we suppose that the cremaster muscle, by its exertion, brings down the testicle to the ring, how does it pass the ring? For surely we cannot suppose that this muscle, which takes its origin from the internal oblique muscle, consequently within, can contract, not only so as to bring the testicle to the very point of its

origin, but to protrude it past that point, and through the tendon of the external oblique muscle. Animals have the cremaster muscle, whose testicles never descend out of the belly;—again, the vessels of the cord, before the testicle has fully descended, show no marks of being dragged down, for they are elegantly tortuous.

As the testicle passes very slowly from the loins to the ring; so, after it has escaped from the belly, it passes slowly from the ring to the bottom of the scrotum. It commonly remains some time by the side of the penis, and only by degrees descends to the bottom of the scrotum.*

In this change the testicles do not fall loose into the elongation of the peritonæum like a piece of gut or omentum in a rupture;—but carrying the peritonæum with them, they continue to adhere to the parts behind them, as they did to the psoas muscle while in the loins; a point of importance to be recollected.

The communication betwixt the belly and the sac of the vaginalis is very soon obliterated by the adhesion of the upper part, and then the whole extent of the passage (viz. from E to D, in plan third of this series) is shut. When this process is prevented in the first instance, and nature is baulked in the humour of doing her work, as Mr. Hunter observes, she cannot so easily do it afterwards.

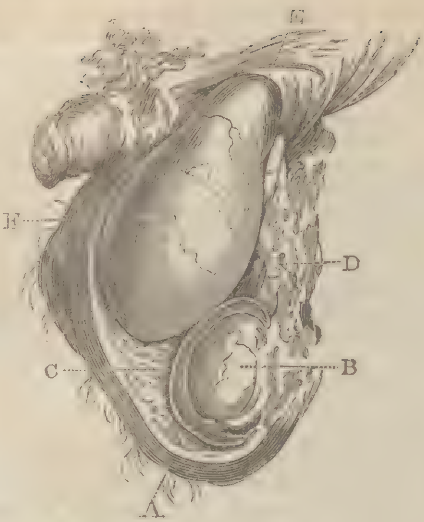
It has also occurred, that this communication remaining after birth, a hydrocele has been produced, owing to the distention of the tunica vaginalis, by fluids descending from the belly. The character of such a tumour will be, that the fluid may be easily forced into the belly. It may be mistaken for a congenital hernia.

It will already be understood, that in the common hernia of the groin or scrotum, the gut does not pass by the communication from the belly into the vaginal coat; that such communication no longer exists, and that when there is a rupture from preternatural wideness of the abdominal ring, or in consequence of a great violence, a new portion of the peritonæum descends with the gut before the cord of the testicle.

FIFTH PLAN OF THE TESTICLE.

This fifth plan will now illustrate the relation of the testicle to the herniary sac in the common scrotal hernia. A, the scrotum: B, the testicle; which will be easily understood to preserve its attachment to the back part of the scrotum: C, the tunica vaginalis, which here invests the testicle, but which is not now (in the adult or perfect state of the coats of the testicle), as is seen in plan third, open from D to E, but forms a short sac, surrounding the tunica albuginea: D, the cellular membrane of the cord of vessels passing down to the testicle. And now there are no remains of the tube of communication betwixt the belly and vaginal cavity; it is obliterated and resolved into this cellular membrane.

* Mr. Hunter has shown, that the detention of the testicle in the belly is in consequence of some defect and want of action in the testicle, and that those who have the testicle remaining in the belly have it imperfect or small. This is contrary to an old authority:—The testicles are seated externally, "for chastity's sake; for such live wights as have their stones hid within their body are very lecherous, do often couple, and get many young ones."

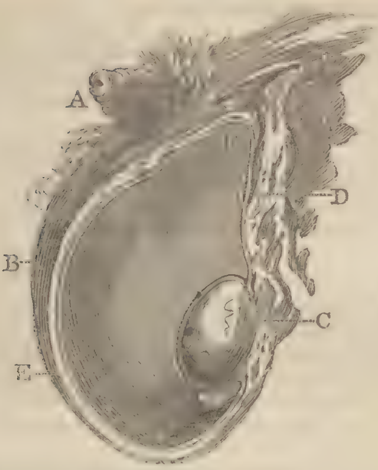


We see, then, that in this plan the testicle and its coats, and the spermatic cord, are in their natural situation, and that the herniary sac has descended before them. E, is the ring of the external oblique muscle of the abdomen, through which not only the testicle, with its coats and vessels, has descended, but also the hernia: F, the herniary sac, which contains a portiot of the gut; it is formen of the peritonæum, falled down from the belly, bun it is quite distinct from the sac of the tunica vaginalis C. Whilst this new process of the abdominal peritonæum has descended, it has contracted adhesions, and cannot now be replaced.

In thus explaining these important principles of anatomy, which the anatomical student will find wonderfully to facilitate the more minute study of surgical anatomy, it only remains to show the nature of the hydrocele.

The hydrocele is a collection of water within the sac of the tunica vaginalis; that is, betwixt the tunica vaginalis and tunica albuginea. For, as we have seen that the same surface of the vaginal coat is contiguous to the surface of the testicle, (viz. the albuginea) as that of the peritonæum, which is contiguous to the viscera of the belly; and as it has the same exudation, so it has the same disease, viz. a collection of water, from the absorption being disproportionate to the exudation. When the tunica vaginalis is distended with the water of a hydrocele, the testicle is towards the back part of the scrotum: it can be felt there; and when the scrotum is placed betwixt the candle and the eye, we see the transparent sac on the fore part of the tumour, the opaque mass of the testicle behind: generally the distended vaginal coat stretches up before the cord conically, thus:—

SIXTH PLAN OF THE TESTICLE.



A, the penis; it is generally corrugated thus, in consequence of the distention of the scrotum in scrotal hernia and hydrocele: B, the scrotum: C, the testicle, covered only by the tunica albuginea: D, the cellular membrane of the cord: E, the tunica vaginalis, distended with the water of hydrocele, and consequently separated from the surface of the testicle: F, that part of the sac of the vaginal coat, which often extends conically before the cellular membrane of the cord D. Now we see that the distention of the vaginal coat does not open up the old communication with the belly; but that, the former communication being shut, and the peritonæum there degenerated into the cellular membrane of the cord, the hydrocele is a distinct sac, surrounding the testicle, and formed of the tunica vaginalis.

To understand this subject of the coats of the testicle, it is not necessary merely to consider the descent of the testicle; but the student must consider it in every point of view, turn it, as it were, into every variety of posture, without which his difficulties will perpetually return upon him. It is for this reason that I have endeavoured to represent the various states of the coats of the testicle in disease.

I have here used the terms *tunica vaginalis*, and *tunica albuginea*, as my reader will find them interpreted in our best old authors. But we may now enquire a little farther.

When we dissect the coats of the adult testicle, we can follow the tunica vaginalis over the surface of the testicle, and by dissecting, separate it from the testicle, leaving that body covered by a dense membrane. Specimens may be seen in my Collection, where hydatids, forming betwixt these membranes, have separated them in a manner still more satisfactory than can be done by dissection. What terms are we to use

for these three membranes? 1. *tunica vaginalis*; 2. *tunica vaginalis reflexa*; and, 3. *tunica propria testis*.*

OF THE VESSELS OF THE CORD AND TESTICLE.

In attending to the descent of the testicle, we have a clue also to the vascular system. If we did not know that the testicles were originally placed in the loins within the belly, we might wonder at the length and origin of the spermatic vessels.

The SPERMATIC ARTERY rises on one side from the fore part of the aorta, below the emulgent artery, and on the other from the emulgent artery, sometimes they arise from the arteries of the renal capsule; sometimes there are two spermatic arteries to one testicle. This artery, which the cord receives from the aorta or emulgent, is called the superior spermatic artery, because there is another which rises from the hypogastric artery: this branch runs upward, connected to the vas deferens, as it rises out of the pelvis. Another artery is given to the membranes of the testicle from the epigastric artery.

These arteries, taking their course under the peritonæum, join the fasciculus forming the cord, and supply the cord, and send twigs to the investing peritonæum; they then pass through the abdominal ring, and in their course they are beautifully tortuous.

The VEINS of the testicle terminate on the right side in the trunk of the cava, a little below the emulgent vein, and in the emulgent vein on the left side. There is also (accompanying the vas deferens) a vein, which joins the internal iliac vein. All these veins, in their course from the testicle, are protected from the column of blood, and from the consequences of compression, by numerous valves. These valves are very strong, and will bear a great column of mercury before they give way or burst. This plexus of convoluted veins of the cord is the most beautiful in the body; and we may observe, that such convolutions of veins are ever attendant on arteries tortuous in their course, and subject to occasional excitement. And further, if by accident there is excited an uncommon action in the arteries of a living body, that action will be apparent from the distended or enlarged state of the veins. In the testicles of such animals as have their seasons, the artery and veins of the testicle become still more convoluted, and form a mass of vessels, which has been called *corpus pyramidale*.†

The nerves of the testicle, like the blood-vessels, come from the loins: they form a division from the emulgent plexus, and are continued down upon the vessels. This connects the testicles to the abdominal viscera, giving them much of the same sympathies. The stomach, intestines, and testicle, sympathise readily with each other.

* *De Graaff* speaks of the division of the tunica albuginea into two membranes, probably meaning to distinguish the cellular tissue of the body of the testicle from the investing membrane. *Morgagni*, in his commentary on him, tells us he can separate the tunica albuginea into two laminæ, the inner of which is the most delicate. Advers. An. iv. Animad. i.

† Corpus varicosum,—Corpus Pampiniforme; Alias parastatum varicosum; Galen de Semine; Util. partium.—As the old physiologists saw and observed this wonderful tortuosity, and the tendril-like form of the spermatic artery, they thought that the blood was here begun to be changed into semen, and therefore they called them the *vasa præparantia*.

The lymphatics of the testicle are numerous, and easily demonstrated by blowing up the cellular structure of the body of the testicle; and this has been the ground of dispute between physiologists; and the proofs of some important points in the doctrine of absorption have been drawn from the injection of the lymphatics of the testicle and cord.

The CREMASTER MUSCLE, as we have seen in the first volume, takes its origin from the internal oblique muscle of the abdomen, from the os pubis, and, passing down over the vessels of the cord, is expanded on the tunica vaginalis. The use ascribed to it is to suspend the testicle, and prevent it from dragging upon the vessels of the cord; but it is chiefly useful in compressing the body of the testicle, drawing it up, and accelerating the discharge of semen. A very principal use is to compress the veins of the cord, and to support them against the impulse from within.

Thus we find the cord of the testicle, as it is called, to consist of the excretory duct; of the arteries, veins, and nerves; of the lymphatics returning from the testicle; of the cellular tissue embracing and supporting all these vessels; and, lastly, of the fibres of the cremaster muscle.

OF THE STRUCTURE OF THE TESTICLE.

It is to De Graaff that we owe the knowledge of the structure of the testicle; and indeed the merit of this great anatomist has not been acknowledged with sufficient gratitude by modern anatomists: but after the fervour of disputation has subsided, the merit of ingenuity and of discovery must return to him to whom it is due. No one more highly values than I do the improvements of anatomy by the Hunters and Monro; but I must say, that the structure of the testicle was demonstrated by De Graaff to his fellow-anatomists of Montpelier; and his discoveries published in a manner so perfect, as to leave us little to learn from more modern authors.

De Graaff, by exciting the gland of brutes, and tying the spermatic cord, had the seminal vessels distended. He did not depend upon injections: by maceration and dissection in this distended state, he unravelled all the intricacies of their tubes. More modern anatomists have proved the truth of his observations by injections of mercury, and have succeeded in a variety of ways of preparing the testicle.

TUBULI TESTIS.—When the tunica propria testis is lifted, the body of the testicle is found to consist of innumerable delicate white tubes; which, when disentangled from the minute cellular membrane which connects them, and floated in water, exhibit a most astonishing extent of convoluted vessels. By a closer attention, however, to this structure, before it is thrown into confusion by pulling out the tubes, they appear to be regularly laid in partitions of the cellular membrane. These sepimenta are very regular in some animals, and while they separate the seminal tubes, they support and convey the blood-vessels to the secretion of the semen. Dr. Monro has denied the formal divisions which De Graaff had engraved, but admits them less regular, less easily found, and not so limited in their number; nor does he find that they prevent all communication betwixt the tubes of the testicle.

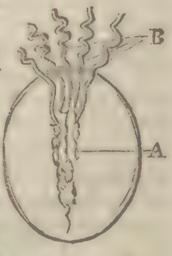
These seminiferous tubes of Haller, or tubuli testis of Monro, run towards the back of the testicle. Each of these tubes seems to be cylindrical, or of one diameter throughout their whole extent: we see no communication betwixt them; no branches given out or going into them; nor have I been able to distinguish a beginning for the whole, nor for any one of them. There seems to be only one tube wonderfully convoluted and folded up in each subdivision of the testicle.

RETE TESTIS. —When the tubuli come out from the body of the testicle, they run along the back of it, and communicate by innoculations with each other, so as to form a net-work of vessels, from which appearance Haller named them rete testis.

Here it often happens, that the mercury stops, when it has been injected backwards from the vas deferens; and it is this part which has been better described and drawn, in consequence of mercurial injections, than it was by De Graaff; for he, as we have said, saw this part only filled with semen.

Connected with the rete testis is the CORPUS HIGHMORIANUM.—Where the lines of the membranous septa, and cellular membrane of the testicle, meet on the back of the testicle, and under the epididymis, they form a white line. This white line running along the testicle, was supposed by Highmore to be a hollow tube; it was compared with the salivary duct; it was thought to be a cavity leading from the body of the testicle to the head of the epididymis, and to form the communication by which the semen flowed from the testicle. De Graaff first refuted this notion, and showed that it was not by this one great duct, but by these smaller tubes forming what has been now called the rete testis, that the semen came from the testicle: still it had continued a question, whether this white line was really solid, or a tube; and upon faithful examination of the point it appears, that this is expressly as it was explained by De Graaff, viz. that it is a mere collection of the membranes of the body of the testicle, forming a linea alba; and as the septa are more distinguishable in some animals, so is the corpus Highmorianum.*

VASA EFFERENTIA.—The tubes running on the back of the testicle, and forming the rete testis, we have understood to arise from the tubuli testis; now it is the continuation of the rete testis which is called vasa efferentia. The vasa efferentia are very delicate vessels which run out from the head of the testicle, single at first, but they are soon convoluted, and by these convolutions they are formed into an equal number of *vascular cones*, which constitute the head or larger part of the epididymis. These vasa efferentia and vascular cones are connected by a very delicate cellular membrane; and it is a piece of very nice dissection to display them after they are injected with mercury.†



EPIDIDYMIS. — The vasa efferentia, after forming these conical convolutions, unite, and form larger tubes; these again unite, and form one large excretory duct, the *vas deferens:* and this vessel, being convoluted to a wonderful degree, forms a body,

* This body is called a mere *firmamentum* or binding.—Winslow.
† Description of the figure:— A, Rete testis. B, Vascular cones.

which, being as it were placed upon the testicle, has been called epididymis.

In the substance of the testicle there are no glands nor follicles; the arteries minutely ramify amongst the seminal tubes, and, there is reason to believe, secrete the semen into them. The seminal vessels in the subtance of the testicle, or tubuli testes, run together upon the surface of the testicle, and form the rete testis. From the rete testis are continued the vascular cones: these convolute, and, running together, form the epididymis; from which the tube is continued under the name of the vas deferens. It passes up the cord, enters by the ring into the abdomen, and then, passing down into the pelvis, terminates in the vesiculæ seminales, in a manner presently to be explained. It is not likely that the vis a tergo, the power of the arteries, pushes the semen through all this length of tube, of which the epididymis itself is reckoned to be several feet in length, if the various convolutions were undone; such an action on the testicle as that of the dartos or cremaster muscle could give only a general pressure, but could not force on the semen in tubes which take so great a variety of directions. We are therefore left to the supposition, that these tubes themselves have a power of accelerating the fluids through them.

There is a duct which sometimes arises from the epididymis, and which we find to terminate abruptly in a blind end:—of this, Mr. Hunter speaks in the annexed note.*

OF THE TESTICLE IN GENERAL.

The testicle is of an oval form, and of the size of a pigeon's egg; it is a little flattened on the sides: it hangs in the scrotum by the spermatic cord; one end of the oval, forward and high; see plan seventh, B; while the other is backwards, and drops lower, C. The spermatic cord consists of the artery which brings blood; of the veins which return it; of the vas deferens, which carries the semen to the vesiculæ seminales at the neck of the bladder; of lymphatics, which are essential to the structure of every part. This cord of vessels comes down from the belly, and passes by the ring of the abdominal muscles: it is

* "By a supernumerary vas deferens, I mean a small duct, which sometimes arises from the epididymis, and passes up the spermatic cord along with the vas deferens, and commonly terminates in a blind end, near to which it is sometimes a little enlarged. I never found this duct go on to the urethra, but, in some instances, have seen it accompany the vas deferens as far as the brim of the pelvis. There is no absolute proof that it is a supernumerary vas deferens; but as we find the ducts of glands in general very subject to singularities, and that there are frequently supernumerary ducts, there being often two ureters to one kidney, sometimes distinct from begining to end, at other times both arising from one pelvis: these ducts arising from the epididymis, I am inclined to believe from analogy, are of a nature similar to the double ureters. They resemble the vas deferens, as being continuations of some of the tubes of the epididymis, are convoluted where they come off from it, and afterwards become a straight canal passing along with it for some way, when they are commonly obliterated.

"The idea of their being for the purpose of returning the superfluous semen to the circulation is certainly erroneous, from their being so seldom met with, and so very seldom continued further than the brim of the pelvis." Many examples of this may b seen in my Colleetion.

about four inches in length, and is fixed into the upper and back part of the body of the testicle.

The body of the testicle is easily distinguished, and is the place where the secretion is performed. It is strictly the body of the gland, while the part above it is only the duct by which its fluid is discharged.

The ancients called the testicles didymi, gemini, twins; they, therefore, called that part which is laid on the back of the testicle epididymis, as added to it. To the surgeon, it is essentially necessary to attend to the relation of the parts of the testicle as felt through the scrotum.

SEVENTH PLAN OF THE TESTICLE.

In this seventh plan, fig. 1., we see the testicle as in its natural situation, covered with its membranes, and appearing like one body; while in the second figure, it being represented freed from its outer coat, we see the epididymis as laid upon the testicle, and consisting of the convoluted tube. First we observe A, the body of the testicle: B, the beginning of the epididymis, or the large head of the epididymis*: then we see it laid along the back of the testicle, and observe C to be the small head of the epididymis†, where the tube is reflected to re-ascend upon the testicle, and to form D, the vas deferens.

Now, we have to observe, that the point C, fig. 2., or small head of the epididymis, hangs over the testicle, and points backwards to the perinæum, and can be felt through the whole coats; and that the body of the testicle A, is towards us when we examine a patient.—Further, as the letters in figures 1. and 2. refer to the same points, we have only to notice the fainter indication of the parts in fig. 1., it being invested with the coats; and to observe the general relation of the testicle to the scrotum and penis.

* *Globus major*, or head.

† *Globus minor*. This part we often distinguish retaining its hardness after the subsiding of the general swelling of hernia humoralis. From this point we can trace all the connections of the other parts.

There is one other circumstance to be observed, viz. that the epididymis is always laid on the outer side of the insertion of the cord into the testicle; from which we distinguish, with ease, in a preparation, to which side the testicle belongs. Thus, in the annexed plans, the testicle of the left side is represented, which we know from the points C, being directed backward, while the epididymis is laid along the left side of the insertion of the cord.

OF THE VESICULÆ SEMINALES.

Behind the prostate gland, and attached to the lowest part of the urinary bladder, lie two soft bodies, the vesiculæ seminales. They appear like simple bags when seen from without, but dissection shows them to consist of a cellular structure: each of these bodies is about three fingers' breadth in length; their backmost point is large and round, and at the same time that they diverge from each other, their narrow points unite, or are contiguous to each other forwards, and enter at the back part of the base of the prostate gland.

As we have seen, the peritonæum does not descend far enough betwixt the bladder and rectum to cover or invest these vesiculæ; they are therefore involved in the cellular texture, and covered with strong fibres, besides being subject to the compression of the levator ani muscle. When the vesiculæ are cut into, and especially when they are distended, dried, and cut, they appear cellular; but if they are carefully dissected, they present the appearance of a convoluted duct.

This cellular appearance is produced by the duplication of their inner membrane, together with the distortions and curves of the canal. Their outer surface is covered with a fine membrane, which connects these cellular convolutions.

The vesiculæ are copiously supplied with arteries: their surface is covered with veins and lymphatics. Heister, Winslow, and others, have described small glands seated in their sinuosities; but these are confidently denied by others. These vesiculæ are themselves glands, or, in other words, the arteries secrete into them a peculiar fluid. The fore part of each of the vesiculæ, which we have said sinks into the back part of the prostate gland, runs under the neck of the bladder, and opens by a distinct mouth into the urethra on the surface of the verumontanum.

The connection of the vas deferens with the vesiculæ is very particular: the duct and the extremity of the vesicular tube join, and they together open into the urethra.

There is nothing in the human structure to discountenance the idea that the semen may pass retrograde from the vas deferens into the vesiculæ seminales; but as in some brutes the vas deferens has no connection with the vesiculæ seminales, it is to be presumed that they are not mere receptacles of the secretion of the testicles.

The extremity of the vas deferens joins the duct of the vesiculæ where it is imbedded in the prostate gland: the union of the vas deferens and duct of the vesiculæ is not attended with an enlargement of the duct; on the contrary, as the duct passes forward deep into the substance of the gland to arrive at the urethra, it becomes remarkably narrower until it opens in a very small orifice in the verumontanum. The duct (if we may so call it) of the vesiculæ passes a considerable way into the gland before it terminates in the urethra.

The vesiculæ appear to be useful in adding a fluid to the secretion of the testicle, which being poured together into the sinus of the urethra, are then sufficient to distend this part of the canal, by which the ejaculator muscle is excited, and effect given to its action; for a smaller portion of fluid would not be carried forward by its contraction; unless there were a provision of fluid sufficient to distend the sinus of the urethra, the semen could not be thrown out from the urethra. This supposition is not opposed by the facts stated by Mr. Hunter, that in many animals the vesiculæ and vasa deferentia open by distinct foramina into the urethra, because in that case the fluids of these secreting bags might be equally mingled with the semen in the sinus of the urethra, although they do not flow from the same tube.

Verumontanum.—The verumontanum, or caput gallinaginis, is an eminence on the lower part of the urethra, where it is surrounded by the prostate gland. It is larger and round towards the bladder, and stretches

with a narrow neck forwards. On its summit, the two orifices of the seminal vessels open; and around it there are innumerable lesser foramina and mucous follicles, the ducts of the prostate gland.

The SINUS POCULARIS is the sac or large lacuna formed within the caput gallinaginis; its mouth is directed forwards, so that the urine flowing out of the bladder lays the margin down, and as the seminal orifices open within the margin, they are by this means protected from the urine. Sometimes the ducts are found opening on the sides of the sinus.*

* Mr. Hunter rests his opinion of the vesiculæ not being receptacles of the semen principally on these facts. The fluid contained in them does not resemble the secretion of the testes. Of this he satisfied himself in a man shot by a cannon ball, whom he examined immediately after he expired. A fluid is sometimes emitted in straining at stool, which he considers to be from the vesiculæ. A gentleman could emit semen in the common quantity, immediately after this had escaped. He found in several instances, where one testicle had been extirpated, that the vesicula on the same side was full of its usual fluid. In one subject he found the vesiculæ full, when there were neither perfect vasa deferentia, nor ducts leading to the prostate. The vesiculæ are distended in the weak as well as in the strong; in the old as in the young. In different animals the vesiculæ and the testes vary greatly in their relative sizes. The contents of the vesiculæ are different, while the semen continues the same. In different animals the ducts open unconnected with the vasa deferentia. The fluid in the vesiculæ seminales of the gelding and the stone-horse has the same appearance: these bags are larger in the latter: and the contents are very different from the semen in the stone-horse. Some animals have no vesiculæ. Birds have not got them, and they copulate many times successively, and thus appear to require a receptacle.

That the vesiculæ are in some way subservient to generation, he believes, because, as there are variations in the developement of the testicles, in those animals that have their seasons, so there is a corresponding variation in the developement of the vesiculæ. This is analogous, he thinks, to the diminution and the growth of the prostate gland in the same animals, according to their seasons. The deprivation of the testicle makes various parts concerned immediately in generation shrink, as the penis and its muscles.

He concludes that the bulb of the urethra is the receptacle in which the semen is gathered before emission, and not the vesiculæ; that these are for secreting a peculiar kind of mucus, of which he has not ascertained the use. See Animal Economy.

THE

ANATOMY

OF THE

FEMALE PARTS OF GENERATION.

THE ANATOMY OF THE PARTS IN THE FEMALE PELVIS.

The parts of generation are divided into the external, which are those without the pelvis; and the internal, or the viscera of the pelvis, which lie within the bony circle of the true pelvis.

THE EXTERNAL PARTS OF GENERATION.

The external parts of generation are the mons veneris, labia, clitoris, nymphæ, urethra, hymen, and carunculæ myrtiformes. Upon these subjects we have no want of books and information; for accoucheurs of the old school dwelt upon the description with particular accuracy. These parts were within their ken, which we cannot say of the viscera of the pelvis; and therefore upon this first head we shall be more brief.

In very young children these external parts bear a large proportion to the body, greater than at any subsequent period before the age of puberty. From the age of two years to twelve or thirteen, there is little increase. At puberty they are suddenly and completely evolved. Preceding menstruation and the developement of the uterine system, the whole parts, internal and external, partake of a sudden impulse. They become turgid and vascular: the fat is deposited in the surrounding cellular membrane.

About the fortieth year, when the menses disappear, this fulness of the private parts also ceases, and the fat is re-absorbed.

The mons veneris is that prominence on the symphysis pubis, which consists of the skin raised and cushioned up by the fat inclosed in the cellular membrane. There is a great variety in its size. In early life it is small: it becomes, as we have said, more prominent at the age of puberty: in fat women it is of an enormous size; and in some warm climates a particular laxity prevails. From the hair on this part, marking the age of puberty, it is called pubes. As the lax tex-

ture admits of distention with the fluid of anasarca, it is sometimes from this cause very greatly swelled.

The LABIA.—These are often named alæ, from a slight resemblance to wings, and they are also called alæ externæ, magnæ, or majores, from their place, and from their superiority in size over the nymphæ. The labia seem to be the mons veneris continued downward and laterally, until meeting below, they complete the circle of the vulva; at their lower angle by their union they form the fourchette, or frænum labiorum. The structure of the labia is similar to that of the mons veneris: sometimes one is larger than the other.

The great sensibility of the membrane which lines the inside of the labia requires some defence, and therefore the whole surface is amply supplied with mucous follicles and glands. The labia are a protection to the other soft parts. If the clitoris or nymphæ project beyond them, they are subject to violent inflammation.

The parts here have either such folds, or are of so lax a texture, as to permit a great degree of distention during the passage of the child. But as the labia have no muscular power, and depend entirely on their elasticity for restoring them to their original size, they commonly, after being very much dilated, remain in some degree larger and more lax. It is different with muscular parts, as the orificium externum, which, by the power of its sphincter, is restored after labour to its original size. In man, hernia descends from the abdominal ring into the scrotum; but, in woman, when there is a rupture from the ring (which is rare), it falls into the labium.

The NYMPHÆ are named labia vel alæ minores, or labia interna, to distinguish them from the great labia. They are like a miniature representation of the great labia: they are covered with a very delicate membrane, and have great sensibility. They begin immediately under the glans clitoridis, and seem to be only an extension of its præputium, formed by a folding of the membrane. Their size varies much. They commonly stretch downward and backward to the middle of the orifice of the vagina; sometimes no further than to that of the orificium urethræ, and in a few instances they extend even in the length of the fourchette.* They are very vascular, and have somewhat of a cellular structure, and thus partake of a degree of turgidity, in consequence of irritation and vascular action. The most modest of the uses ascribed to them is, that of directing the stream of urine. As they are obliterated during the passage of the child's head through the vulva, it is probable that they facilitate the necessary dilatation.

The nymphæ are, in their natural situation, covered and completely protected by the labia externa. When naturally large or increased by disease, or in a very relaxed state, they are deprived of this covering: they project from under the labia, and are apt to become inflamed, and even to ulcerate. The original disease, or tumour, is augmented, or they become, perhaps, hard and callous. In children they bear a very great proportion to the other parts, and are more conspicuous and prominent than in the adult. When enlarged by disease they some-

* Both Riolin and Morgagni have seen the parts without the nymphæ.

times require to be extirpated; in which operation, as they are very vascular, and as with their growth their blood-vessels enlarge, considerable hæmorrhage may be expected.

The CLITORIS is similar to the male penis. Like the penis it consists of cells for receiving blood; and in a similar manner, it arises from or takes hold of the rami of the os pubis by two crura: these unite at the symphysis pubis, to form the body of the clitoris, which is suspended from the os pubis, like the penis, by a kind of ligament. The clitoris has also a kind of glans, over which the integuments make a fold like a præputium. In short, it has the same sensibilities, the same power of erection with the membrum virile; only it has no urethra nor spongy body, like that of the urethra of man, and is so small as to be hid within the labia.

The stories of the increase of this, even to its pre-eminence in size over the penis, are very idle. It is not wonderful that a clitoris of such magnitude should suggest the idea of a hermaphrodite, or person partaking equally of the distinguishing attributes of either sex.

OF THE URETHRA.

The urethra of the female is short, straight, and wide; its length an inch and a half, or two inches: its direction nearly straight, or only slightly bending under the os pubis; and its diameter such as will admit a catheter the size of a writing quill. The consequences of these peculiarities are, that the catheter is easily passed when there is no very unusual obstruction; that women are not so much exposed to the disease of stone in the bladder as men; for though this is much owing to constitutional peculiarities, yet it is obvious, that when a small stone is formed, and passes into the bladder, it is more easily discharged in this sex. If it does not pass with the gush of urine, yet the canal can be dilated, so that a very considerable calculus may be discharged without incision.

The opening of the urethra is in a direct line under, or behind, the clitoris, and about an inch from it: it is in the middle of a slight prominence, and its vicinity is plentifully supplied with mucous glands. If the relation of the orifice to the clitoris be observed, there is, in the natural state of the parts, no difficulty in slipping the point of the catheter, on the end of the middle finger, from the clitoris, until it is caught upon the lacuna-like orifice of the urethra.

From the length and sudden turns of the male urethra, from the double function it performs, and from its being embraced by the prostate gland, the obstructions of the urine are more frequent, and the catheter less easily passed, than in woman. The catheter, too, requires to be of a very peculiar form. The short and wide urethra of woman requires only a simple and almost straight tube; and although accurately to adapt it to the course of the urethra a considerable curve might be given to it, yet that is not necessary in common cases; and circumstances will occur to the accoucheur which will preclude the possibility of using such an instrument.

We shall only mention here such cases of obstruction of urine as

are in a particular manner illustrated by the anatomy and connection of the parts. These are tumours of the ovarium, tumours of the womb, polypi, distention of the vagina, displacement of the womb, as procidentia, prolapsus, retroversio, &c.; and, lastly, the child's head, in labour.

The ovarium being enlarged, and falling down into the pelvis, either presses upon the neck of the bladder, causing obstructions, or pressing and weighing on the fundus of the bladder, it occasions a stillicidium urinæ.

Tumours of the womb, especially of the neck or orifice, as it is in contact with the urethra, very soon affect this organ. Thus, I have seen a cancer of the orifice of the womb, by exciting inflammation in all the surrounding parts, and by massing them together into a tumour filling the pelvis, occasion obstinate obstruction of urine.

Polypi attached to the orifice of the womb, and filling the vagina, produce the same effect. In all such cases, perhaps, the tumour may be pushed up, so as to permit the flow of urine, or the introduction of the catheter.

A case occurred to Mr. John Bell, in which the tumour of the womb compressed the neck of the bladder. A catheter was passed, and gave instant relief. The midwife, after some time, came, and said, that the catheter would not pass. He found that he could pass the catheter into the bladder, but no urine flowed; and it was discovered, that the tumour, increasing backward, came to press upon the ureters, so as completely to obstruct them where they enter the bladder. The woman unavoidably died; each kidney and ureter was found to contain four or five ounces of urine.

A slight sketch of the parts in the female pelvis will, perhaps, better explain the connections of the neck of the bladder than any description, and will certainly better illustrate the cause of some kinds of obstruction, particularly that arising from the change in the posture of the womb.

FIRST PLAN OF THE FEMALE PELVIS.

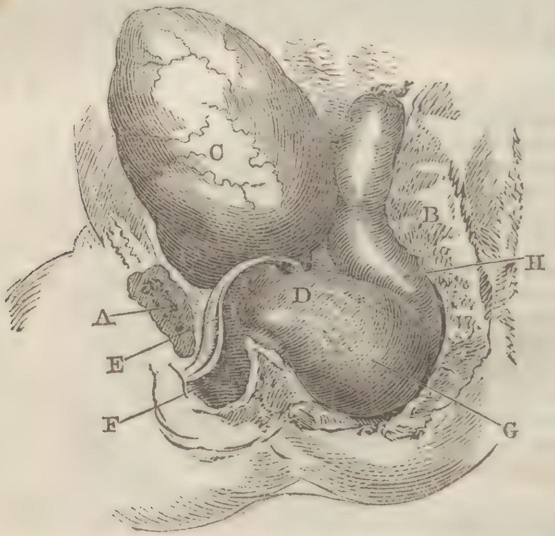
A, the os pubis cut through : B, the spine and sacrum also cut directly down : C, the urinary bladder moderately distended, and rising behind the pubes : D, the urethra, very short, and taking a gentle curve under the symphysis of the os pubis : E, the womb : G, the vagina : the os tincæ, or orifice of the womb, is seen projecting into it : H, the rectum.

Prolapsus, or falling down of the womb, is frequent with those who have borne many children. By this slipping down of the body of the womb E, into the vagina G, it presses on the neck of the bladder, or urethra. This is also apt to happen in the first months of pregnancy, from a degree of difficulty which the womb in its enlagement has in rising above the brim of the pelvis.

We may observe also from the place of the vagina G, that its diseases, its scirrhous hardening, its distention by the menses, will also compress the urethra and neck of the bladder.

The retroversion of the womb is the most formidable obstruction to the urethra. It is produced by distention of the bladder acting on the womb in a particular situation, and is the cause of suppression of the urine. When the womb in the third or fourth month of gestation has increased so much as to produce a degree of compression on the surrounding parts, and to rise above the brim, and shoot up into the abdomen, a distention of the bladder is apt to throw the fundus under the projection of the sacrum. We have to observe the connection betwixt the back and lower part of the vagina. By the distention of the bladder, the vagina is stretched, and the orifice of the womb is raised, which throws back the fundus of the womb, so that this comes to be the situation of the parts.

SECOND PLAN OF THE FEMALE PELVIS.



A, the os pubis : B, the sacrum : C, the bladder of urine much distended, and rising above the pubes : D, the connection betwixt the back part of the bladder and the upper part of the vagina, and through which the rising of this part of the bladder (in consequence of its distention) has drawn up the orifice of the womb, and thrown back the fundus : E, the orifice of the womb, which, being raised and turned up, no longer presents so as to be felt by the finger in the vagina. It will be observed, also, that the womb now lying across the pelvis, this lower part is forced against the neck of the urethra, so as to compress it, and cause total obstruction of urine. F, the vagina, which is stretched in consequence of the rising and turning up of the orifice of the womb : G, the fundus of the womb enlarged and distended by impregnation, fallen back under the promontory of the sacrum, and compressing the rectum H.

Now, when the fundus of the womb is thrust back, and the orifice raised by the distention and consequent rising of the bladder, the natural and simple cure is to introduce the catheter, and draw off the urine. But should this not be done at first, then there being distention of the bladder, and pressure on the rectum, the abdominal muscles sympathise with these parts, so that bearing-down efforts are made, and the fundus of the womb is forced further down into the hollow of the sacrum, while the orifice is directed upward.*

Were this distention to happen at any other time than just when the uterus is of such a size, that being thrown back, it catches under the sacrum, and does not rise again, no harm could follow.—I attended a woman afflicted with obstruction of urine, who died. I afterwards opened the body, and found that the womb, being enlarged by disease, had produced much the same effect as if it had been enlarged by pregnancy, viz. obstruction of the urethra ; for the body of the womb had fallen into the hollow of the sacrum, and had formed adhesions there with the rectum, while the orifice of the womb pressed forward upon the os pubis, so as to produce an obstruction of the urine. The parts were otherwise diseased, but this was the cause of the fatal termination of the complaint.

As we treat of those subjects only as connected with the urethra, we may observe, that sometimes the urethra takes a course not round behind the os pubis simply, nor straight upwards, but curved backwards, so that the convexity of the catheter requires to be towards the sacrum, to allow the point to pass over the orifice of the womb, or perhaps the flexible or the male catheter may be required.

The effect of the wedging of the child's head in a tedious labour is to elongate and compress the urethra in a very particular manner. Many young men have felt the difficulty of introducing the catheter in this case. But it is a difficulty proceeding generally from ignorance or inattention. I believe there never occurs a case in which the child's head is so firmly impacted that the catheter cannot be passed ; but often practitioners forget the direction which the urethra necessarily assumes, when the child's head has sunk into the pelvis.

* See a preparation in my Collection, with the accompanying drawing and model. Cases by Dr. Wm. Hunter, in the Medical Observations and Enquiries.

ORIFICIUM VAGINÆ.—This is also named ORIFICIUM EXTERNUM, in distinction to the uterine orifice. I notice it under the head of the external parts, because we have to speak of the parts which surround the orifice, as the hymen.

All anterior or external to the orifice of the vagina and within the labia is the vestibulum. The orifice of the vagina of the human female is abridged by the hymen, which is a peculiar membrane. It is of a semilunar form, and sometimes surrounds the lower part of the orifice of the vagina;—commonly it surrounds only the lower half of the circle, though it would seem to vary considerably in shape, place, and strength. It has been found surrounding the whole circle of the orifice, leaving only a small hole in the centre or upper part; or it is described as perforated with lesser holes, allowing the evacuation of the menstrual blood. In other cases, it has been found a complete septum, preventing the evacuation of the menstrual blood. This is a fact which I do not dispute, for I know that the perforation for the evacuation of the menstrual blood is sometimes necessary.* When I have seen the imperforated vagina in the child, it was not the hymen which closed the orifice, but an adhesion of its sides; yet this adhesion, if it had come to be distended with the menstrual blood of several periods, would have presented the appearance of a tense membrane stretched across the orifice.

Such semilunar membrane as I have described will occasionally be seen in the female parts; but it has such an appearance as may easily be destroyed in the preparation of the parts, if the anatomist be inattentive or careless. It is neither a guard, nor is its existence a test of female chastity. Often in tender children there is no such thing to be seen; while, on the other hand, it has been cut to admit of labour and delivery.† Either of these facts is sufficient proof of the idle notions entertained concerning this membrane, and that when present it is, like a contracted præputium in the other sex, a defect.

The CARUNCULÆ MYRTIFORMES—are small and irregular tumours at the back, or lower part of the external orifice: they are seated rather at the sides than exactly at the back part: they are supposed to be the ruins of the hymen, which being lacerated, shrinks into two or three tumours on each side. Some have said, that these exist originally joined together by a thin membrane, or delicate tissue of small vessels, the rupture of which causes an effusion of blood. They seem to be simply corrugations of the inner membrane, which serve as a provision for the dilatation of the parts; and they accordingly disappear during the passing of the child's head.

The FOSSA NAVICULARIS is a sinus, supposed to be of the shape of a boat, whence its name. It is formed betwixt the proper orifice of the vagina and the fourchette, or joining of the labia at their lower edge. It is more conspicuous in young subjects.

* See a case by Mr. Tynney, in Duncan's Med. Comment. vol. iii.

† I need not say how unnecessary and improper such operations are. All rigidity, callosities, even tumours, and undoubtedly the hymen, will yield to that general relaxation of all the parts, which takes place upon the commencement of labour.

From the meeting of the labia below, the PERINÆUM commences: it includes the space from the frænum to the anus.

OF THE PARTS CONTAINED WITHIN THE FEMALE PELVIS.

THESE parts are the bladder of urine, the vagina, the womb, the ovaria. We shall consider them under distinct sections.

OF THE BLADDER OF URINE.

As the coats of the bladder of urine in woman do not vary from those of the male bladder, we have under this head only to notice the peculiarities in its relative situation. It is seated behind the os pubis, and betwixt it and the womb; and, on its lower part, it is attached to the vagina: upon the neck of the bladder, or the beginning of the urethra, there is not a body like the prostate gland; and as we have seen, the urethra is short, wide, and straight, and simple in its use.

Women are not subject to calculi, and the operation for the stone is rare in them; for, as already observed, when the nucleus is formed, or when a stone slips down from the pelvis of the kidney, it passes from the bladder with much greater facility than in the male parts. The urethra, of itself, has been known to dilate so as to allow very large stones to pass, or it has been artificially dilated. Indeed, the old operation for lithotomy was rudely to dilate, or rather tear, the urethra; and the modern operation is simply to thrust the gorget along the grooved staff, so as to lay open the side of the urethra and neck of the bladder, by an incision above the vagina. Sometimes nature has effected her own relief by the stone working from the neck of the bladder into the vagina. A woman had, for a very long period, suffered great distress, not only frequent desire to make urine, and the urine turbid and bloody, but all the usual symptoms of stone violently aggravated: she was delicate and timid, and concealed her distress, until the urine had run for some time by the vagina. After she had been exhausted by long suffering, her friends insisted that she should allow an examination, when a stone was found partly in the bladder, with one of the rough ends projecting into the vagina. The opening was enlarged, and the stone extracted.

We must, in all cases, recollect the connection of the upper part of the vagina and orifice of the womb, with the back part of the bladder. We have seen its effects in producing retroversio uteri. We must also attend to this connection, as tending to the displacement of the bladder in the procidentia uteri. The uterus sinking into the vagina, and the upper part of the vagina being at the same time reflected into the lower part, pulls down the bladder with it, and when (the disease increasing) the womb covered by the vagina comes to hang from the external parts, it has happened that the bladder has sunk down and

lain upon the fore part of the tumour, but of course within the everted vagina.

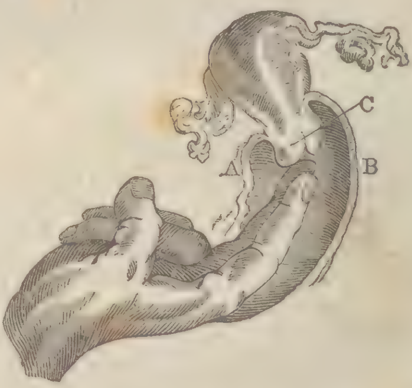
OF THE VAGINA; OF ITS SHAPE, CONNECTIONS, ETC.

The vagina is a tube stretching from the external orifice to the orifice of the womb. Its orifice is bounded below by the fourchette; above by the arch of the pubis; and directly over it, or sometimes within it, is the orifice of the urethra; below, are the carunculæ myrtiformes. It is surrounded by fasciculi of fibres, which are called the sphincter muscle. The canal of the vagina is of a conical form. At the outer orifice it is constricted by the sphincter muscle; but it is wider within, where it receives the orifice of the womb. It may be distended to almost any degree, but naturally its sides, by their own elasticity, the fulness of the veins which are upon it, and the contraction of the surrounding fibres, are in contact.

In the natural state, the orifices of the vagina and womb are but three or four inches distant, often only two; and sometimes, where there is a degree of relaxation, they are nearly in contact. In the first months of pregnancy, the orifice of the womb is kept down by the degree of difficulty the body of the womb has in shooting up from the brim of the pelvis. But the gravid uterus, rising above the pelvis in the latter months, draws up the orifice of the womb, and stretches the vagina.

The vagina bends gently round the pubis, or follows the axis of the pelvis; and as the interior of two circles cut off by the same radii is the shorter, the vagina is longer behind than before.

And thus (*in this plan*) the fore part of the vagina A, is shorter than the back part B. We may observe from this plan, also, that the orifice of the womb C, projects as it were into the vagina, so that the finger touches the os tincæ, and chiefly its anterior lip, without reaching the upper part of the vagina.



The vagina takes its curve nearly in the centre of the pelvis; it is of necessity attached by cellular substance to the rectum and bladder. The urethra, as we have said, opens above the orifice, and that canal is attached to the vagina in its whole length, the neck of the bladder being attached to its upper part. In consequence of this natural connection, disease

of the vagina sometimes throws the whole parts, the rectum, vagina, and bladder, into one fistulous ulcer.

The vagina has three coats; that is to say, it has the inner coat, a few muscular fibres dispersed around it, and exteriorly a condensation of the surrounding cellular membrane, which may be considered as the third coat.

The internal, or villous coat, is a reflection of the delicate covering of the external parts. It is of a larger extent, or longer than the others; and is therefore tucked up into rugæ, which run across the vagina. They are more remarkable on the fore and back part of the vagina; they are less in married women, and considerably obliterated by repeated labours.

To supply a viscous secretion for the defence of this surface, there are mucous glands irregularly scattered over it, and they are particularly numerous at the orifice.

The muscular coat is not very strong, nor are the fibres distinct, from which some have doubted their existence, alleging, that there is here only condensed cellular membrane, and that the contraction of the vagina is the effect of mere elasticity. I observe so great a profusion of venous vascularity, that I presume the vagina suffers an inflation of its coats, and, consequently, contraction from an afflux of blood to it. The muscular fibres are, however, as we have said, gathered into fasciculi near the orifice, so as to be distinctly visible.

The firmness in the structure of the vagina supports the womb: the dilatation of the vagina, the relaxation which old age, and frequent labours produce, occasion the falling down of the womb. It is a disease almost peculiar to those who have borne many children, to the old, weak, and relaxed, and to those who are subject to the fluor albus; every flux from the womb, or discharge from the vagina, having a remarkable effect in relaxing the parts.

This, from the nature of the parts, must be an increasing disease; for no sooner has the womb fallen down into the vagina than it becomes a source of irritation, excites a bearing-down pain like tenesmus, an uneasy sensation, a desire to make urine, and an obstruction of urine; all which is explained by the connection of the parts. The womb lodging in the vagina dilates the orifice, and presses long on the perinæum; at last it is entirely forced out, and the prolapsus uteri becomes the procidentia uteri; it is, in truth, a hernia of the womb.

The third and outer coat, as we have said, is formed of the cellular membrane, by which it is connected with the surrounding parts; but the peritonæum comes down upon the higher part of the vagina. This is the reason why a portion of the intestine, when it slips down betwixt the vagina and rectum, forms a kind of hernial tumour in the vagina, and it explains how the water of ascites has pushed down the back of the vagina, so as to be felt externally; indeed, the water of dropsy has been drawn off by puncturing here.

For the greater space, however, the outer cellular coat of the vagina connects it with the urethra on the fore part, and with the rectum behind. From which close connection of parts, we see the consequence of the delay of the child's head in the second stage of labour, that the head lies violently distending, and compressing the parts, while

the woman, exhausted by the previous stage, is unable to complete the delivery. From violent inflammation, with a deficiency of secretion, there arises a cold and flabby state of the parts. When the woman is delivered, the parts have suffered so much, that they slough off; sometimes the urethra is laid open on the fore part, and sometimes the rectum behind.

OF THE UTERUS.

The uterus, or womb, is a firm vascular body of the size of a pear, and in shape not unlike what you may conceive of a flattened pear. At its upper and lateral parts it terminates in the Fallopian tubes; and the os tincæ, or lower part, projects into the vagina. We must, for the convenience of description, distinguish it into these parts:—The upper part is called FUNDUS: it is the part above the going off of the Fallopian tubes. The BODY of the uterus, which is the larger part betwixt the fundus and the narrow neck: the CERVIX is the narrow neck; and the OS TINCÆ, or orifice, is the lower part, formed of bulging lips, which project into the vagina: over this part the inner membrane of the vagina is reflected. We distinguish also the two surfaces, for the womb is of a flattened form. The anterior surface of the body of the womb is convex, but the posterior surface is considerably more convex than the anterior, and even during gestation it keeps this relative figure.

The whole size of the uterus is about three inches in length, and two in breadth, but there is a very great variety in this respect, from age, the effect of pregnancies, and other causes. When, in its usual situations and relations, the fundus is on a level with the brim of the pelvis, or a very little below it. In the fœtus, the womb is like the bladder, considerably above the brim of the pelvis; but in a few weeks, the pelvis enlarging, it sinks deeper, and soon assumes the same situation as in the adult.

FALLOPIAN TUBES.—From the lateral obtuse angles formed betwixt the fundus and the body of the uterus, the Fallopian tubes are continued. These tubes may almost be considered as a continuation of the uterus, did we not find them so very distinct in their subtance. They are about three inches in length, take a tortuous course, and their extremities have an unequal, fringed termination, which is called the FIMBRIÆ.* Their canal is very small towards the uterus, but enlarges; and is open towards the extremity. These canals are the communications by which the ovum formed in the ovarium is carried down into the womb.

LIGAMENTS OF THE UTERUS.—The uses ascribed to the ligaments have been to support the uterus from sinking too deep into the pelvis, and to steady it, and direct it in its ascent during pregnancy. But whatever good they may do in the latter operation, they are certainly unfit for the former.

There are four ligaments of the uterus.

The BROAD LIGAMENT of the uterus is formed of the peritonæum; for this membrane, passing down before the rectum, and ascending again, and covering the neck, body, and fundus of the womb, descends on the fore part, so as to reach the vagina before it rises over the

* Morsus diaboli.

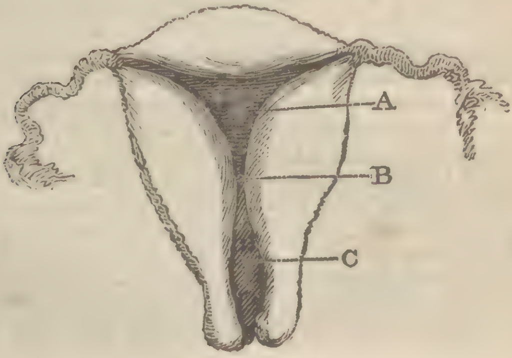
bladder. Thus it invests the womb as it does the abdominal viscera. This investing of the womb with the peritonæum is indeed a provision for its becoming an abdominal viscus, for in pregnancy it rises out of the pelvis, and, being distended before the bowels, assumes, in every respect, that relation to the peritonæum which they have.

As the womb is included betwixt the duplicature of the peritonæum, it is this peritonæal coat which is continued off laterally, and forms the broad ligament of the womb. This duplicature of the peritonæum, forming a fine membrane, has sometimes had the name of ALÆ VESPERTILIONIS: it is, in truth, like a mesentery to the womb and Fallopian tubes, and serves equally to support and convey the vessels to them. The womb and these two ligaments make a complete partition, running across the pelvis.

From the side of the uterus, a little below, and before the going off of the Fallopian tubes, the ROUND LIGAMENTS arise. They are not merely condensed and elastic cellular membrane; but are composed of fibres with an intermixture of blood-vessels, so that whilst they keep a degree of tension on the uterus, they yield and grow not only in length, but in thickness and strength, as the uterus ascends in the advanced pregnancy: they pass through the abdominal ring, and are attached to the cellular membrane of the top of the thigh. In the gravid uterus, both the broad and the round ligaments considerably alter their position, appearing to rise lower and more forward from the womb than in the unimpregnated state. This is a consequence of the greater increase of the fundus of the womb, in proportion to the lower part of it.

What I have here described, and which are commonly called the round ligaments of the uterus, are the tendons of the muscles, and have a very particular use which authors have not observed: at their upper extremity they terminate in a muscular coat, which is spread over the fundus of the uterus, diverging from the tendon. The use of these tendons is to move the uterus in the first approach of labour, and to present the orifice of the uterus to the axis of the pelvis.

OF THE CAVITY OF THE UTERUS.



The cavity of the uterus is properly confined to the fundus and body, for in the cervix it is more like a canal, and differs essentially from the proper cavity. A, *the cavity of the uterus*; B, *the continued cavity*, where it is very narrow towards the cervix; C, *the canal of the cervix*, where it has an enlargement like a sinus. The Fallopian tubes are seen going off from the cavity of the uterus. These angles of the cavity admit no more than a hog's bristle. The third angle, towards the neck, is, of course, considerably larger. The proper triangular cavity of the uterus is lined with a peculiar soft and delicate membrane: it is very vascular, and the vessels either open on the surface naturally, or bursting out, from time to time, pour out the menstrual blood. The canal of the cervix shows a very different surface. We observe a prominent longitudinal line on the fore and back part of it, from which oblique and transverse rugæ go out. The surface is firmer and callous, and less vascular. Betwixt the rugæ there are lacunæ, which throw out a mucilaginous fluid; and towards the orifice we see these larger and sometimes distinct glandular bodies. This peculiar shape of the cavity of the womb, and the hardness and small degree of vascularity of the lower part, is of the most essential importance. The upper part, the proper cavity of the womb, is prepared for the reception and immediate adhesion of the ovum, when it shall have descended through the Fallopian tube; but the long callous cervix is provided, that there may be no adhesion to the lower part of the womb, and that the placenta may not form over the orifice of the womb; for if it should, the most dangerous kind of flooding takes place on the approach of labour, from the opening of the orifice, and the tearing open of the adhesions of the placenta, before the child can be delivered. The length of the cervix, and the glandular structure of the orifice, are also of much importance in sealing up the cavity of the womb after conception, that there may be no longer a communication with the vagina: for this purpose, a viscid tenacious mucus is poured out; but on the approach of labour, with the softening and relaxation of all the soft parts, this adhesion and gluing up of the orifice is dissolved, and a more fluid secretion is poured out.

From the cavity of the womb the MENSTRUAL BLOOD is discharged at certain periods, from the time of puberty to the approach of old age, when the system is no longer capable of giving nourishment to the fœtus.

It was long disputed from what source the menstrual discharge flowed. Some affirmed, that it must flow from the vagina, and not from the womb, because it flowed sometimes during gestation. This is a fact which cannot be denied. I have attended a patient who menstruated during the entire period or to the eighth month; and I have often observed ladies to menstruate at the first period after conception. On the other hand, we have every proof of the discharge being from the orifice of the womb. For instance, some have observed on dissection of the parts of women dying during the flow of menses, that blood was effused under the delicate membrane of the cavity of the womb. The vessels there have been observed particularly turgid, or the whole surface of the proper cavity, and especially the fundus,

spotted with bloody effusions. More particular observation has shown not only the mark of blood poured out from the inner surface, but that the whole substance of the womb was become thick, soft, and vascular *; and M. Littre affirms, that in the body of a woman who had died during menstruation, and with a conception in the Fallopian tube, he found a layer of red coagulated blood; upon removing which he saw a number of small foramina which admitted bristles.†

But the best and least equivocal proof is that which has been repeatedly observed in the inversion of the womb, when the inner surface has been turned out after labour, and has remained thus inverted, and protruding from the external parts; for then the menstrual blood has been seen to distil from the surface of the cavity of the uterus.‡

OF THE BLOOD-VESSELS OF THE WOMB.

There are four large arteries which supply the system of the womb, and four large veins which return the blood.

The SPERMATIC ARTERIES come down from the aorta itself, or from the renal or capsular arteries. The spermatic artery taking a waving direction, becomes tortuous in a most remarkable degree as it approaches the uterus: it is distributed to the Fallopian tube, and ovarium, but chiefly to the body and fundus of the uterus, where it forms remarkable anastomoses with the artery of the other side.

The LOWER ARTERY,—the UTERINE ARTERY, comes in general from the hypogastric artery, takes also a serpentine course, and is distributed to the vagina, and the lower part of the uterus, and inosculates largely with the other vessels, both in the uterus, and by particular branches on the side of the uterus.

In the first place, it appears, that this copious supply of vessels to the uterus, from four different sources, is a provision that the womb and secundines shall not by any accident of position, or by the progress of labour and the consequent compression of one or both the lower vessels, be deprived of their due supply of blood. Again, their tortuous forms give proof of their occasional greater activity, that they admit of a peculiar and local action during menstruation, and that the blood will move more languidly when the stimulus of the womb has ceased. It is also a provision for the growth and increase of the womb, and the supply of nourishment to the ovum. And that an increased activity in a part must be supplied by a more tortuous form, as well as an enlargement of the caliber of the vessels, is in a particular manner illustrated by the change which takes place in

* The authorities upon this subject are Spigelius, Morgagni, M. Littre, Moriceau, Winslow, Sympson.

† This might have been an early abortion, or, perhaps, the decidua, which, it is said, is sometimes formed at the menstrual period.

‡ See Mr. Hill's case in Duncan's Med. Comment, vol. iv. The patient had prolapsus uteri, and she observed, during menstruation, that the fluid came from the orifice of the os tincæ, while none came from the "bag," by which she meant the everted surface of the vagina. She had afterwards fluor albus, and this fluid came from the surface of the vagina. When she had ceased menstruating, the orifice of the womb skinned over.

these vessels during pregnancy. For they become, in a much more remarkable degree, tortuous and enlarged.

The substance of the uterus is said to be spongy and compact, which, though it is a seeming contradiction in words, does yet really convey an idea of the effects of the intertexture of vessels in it. Some have said (as Moriceau), that by pregnancy the womb is distended, and grows thinner: others, that it grows thicker, as Daventer; and others again, as Smellie, assert, that it continues of its natural thickness. These assertions are none of them perfectly correct; for the womb is not distended by the growth of the fœtus and membranes, but grows with them. Again, that the substance of the womb grows in a remarkable degree is true, but still, when distended by the waters in the last months of pregnancy, its walls are thinner than in the unimpregnated state. Thus, when it has been cut in the living body, upon the approach of labour, as in the Cæsarean section, I have observed it not more than a quarter of an inch in thickness, even at the part to which the placenta adhered. When I have dissected the womb, after a tedious labour, the waters discharged, but the head wedged in the pelvis, I have found it considerably thicker. And, lastly, in the full contraction of the womb, after expelling the fœtus and placenta, (for example, in rupture of the womb, where the child and placenta had been forced amongst the bowels, and the woman soon after died,) I found the walls of the womb more than an inch in thickness.*

OF THE OVARIA.

The OVARIA are two oval bodies, which are suspended in the broad ligament behind, and a little below the Fallopian tubes: while they have an oval figure, they are, at the same time, somewhat flattened. By cutting out the ovaria, the animal loses the power of conceiving, and desire is extinguished: they, therefore, bestow what is essential to generation upon the part of the female. In vague speculations on the subject of generation, they were supposed to prepare a female semen! but more particular examination demonstrates that they consist of vesicles which are ova; but how far incomplete, or in what essential circumstance requiring the approach of the male, is not determined.

When we hold the section of the ovarium betwixt the eye and the light, we see a great many pellucid vesicles; and if we examine the ovarium of an animal killed in full health, and particularly in the season, we shall observe these ova to be in all varieties of states of preparation for impregnation. Some small and pellucid, and yet only discernible in the thick outer coat, by having a degree of greater transparency; others which have taken a slight tinge of bloody colour from vessels striking into them; and if the section be made after a minute injection, the vesicles will be seen coloured in the proportion of their maturity; some without a speck of colour; others tinged; one

* See Preparations in my Collection.

or two loaded with injection; and some vascular, and particularly prominent.

In very young girls, the substance of the ovarium is whitish and very soft; the surrounding membrane is thick; and the round corpuscles scarcely discernible; and no irregularities, nor any of those bodies called corpora lutea, are to be seen on the surface. But as the girl advances in years, the little vesicles begin to appear, and when about ten years of age, or just before menstruation, the ovarium is full of ova of various sizes, and some of them more matured, and forming an eminence upon the surface. In the adult woman, the substance of the ovarium, which appeared as an uniform homogeneous mass in the fœtus, is become a cellular and vascular bed, giving nourishment to those numerous vesicles or ova. Before impregnation can take place, there must be a certain state of preparation of the ovaria, without which the approach of the male effects no change in the uterine system. The lower animals having their seasons, and these seasons being a state of preparation for the male, impregnation follows the copulation with much certainty; in women, such a periodical revolution in their system, and instinctive desires, would but ill accord with that superiority in attributes of the mind, which distinguish us in the scale of beings. But women also suffer such an occasional excitement in the uterine system, though unaccompanied with desire, which preserves the womb in a state of preparation for the reception of the ovum, and the ovaria in a state of preparation for impregnation. This is the effect of menstruation.

OF PUBERTY.

Authors have long, with many expressions of surprise, laboured to assign a cause, or frame a theory for the explanation of those changes which we observe in woman at the age of puberty; and, generally, in their theories, they have connected with these changes the monthly and periodical discharges of blood ftom the uterus, which commences with puberty. These theories have been founded, in general, on principles remote from the laws of a living system. At this period of puberty the whole frame is expanded into the fulness of feminine beauty: the breasts rapidly increase, and are matured; the parts of generation are enlarged; the hair of the pubes grows, and the menses flow. In explanation of these changes, theoretical conjectures, after this model, have been entertained:—" About this time the growth of the body begins considerably to diminish, and the blood finding easy admittance into the completed viscera, is prepared in greater quantity, the appetite being now very sharp in both sexes, a plethora consequently follows. In the male it vents itself frequently by the nose, from the exhaling vessels of the pituitary membrane being dilated, &c.; and now the semen first begins to be secreted, and the beard to grow. But, in the female, the same plethora finds a more easy vent downwards, being that way directed, partly by the weight of the blood itself, to the uterine vessels, now much enlarged, of a soft fleecy fabric, seated in a loose hollow part, with a great deal

of cellular fabric interspersed, which is very yielding and succulent, as we observe in the womb: for these causes, the vessels being easily distensible, the blood finds a more easy passage through the very soft fleecy exhaling vessels which open into the cavity of the uterus, as being there less resisted than in its return by the veins, or in taking a course through any other part; because, in females, we observe the arteries of the head are both smaller in proportion, and of a more firm resisting texture. The return of the same is, therefore, more slow, both because the flexures of the arteries, from the increased afflux of the blood, become more serpentine and fit for retarding the blood's motion *, and likewise, because it now returns with difficulty through the veins. The blood is, therefore, first collected in the vessels of the uterus; next it is accumulated in the arteries of the loins, and the aorta itself, which, urging on a new torrent of blood, augments the force so far as to discharge the red blood into the serous vessels, which at first transmit an increased quantity of warm mucus, afterwards a reddish-coloured serum, and by suffering a greater distention, they at last emit the red blood itself. The same greater impulse of blood determined to the genitals, drives out the hitherto latent hairs, increases the bulk of the clitoris, dilates the cavernous plexus of the vagina, and whets the female appetite to venery," &c.

We cannot have trust in so weak a theory; we cannot believe in this plethora, produced by the diminished growth of the limbs; neither can we believe that congestion and plenitude are produced in the female system from the deficiency of perspiration, from their more lax and weaker solids compared with man, from their indolent and sedentary life; for facts are in direct contradiction. The growth and completed function of parts at this particular age is not to be explained by any theory so partially applicable: during almost every period of life there are similar changes taking place in some one part of the body. Parts lie dormant, and are stationary in their growth, which at a particular and stated age of the animal enlarge and develope themselves by a new and invigorated action. Observe how different the proportions of the fœtus are from those of the adult. We see nature careful to perfect certain parts, as the head and liver, at an early period. We see, during early childhood, how the parts shoot out, and evolve in due proportion. We see parts which were large in the fœtus lose their preponderance: we see others, which served some purpose in the fœtal system, gradually shrink and disappear, because they have no longer the stimulus to action in the circle of connections which take place in the adult system. We find other parts, as the teeth, for example, lying long within the jaw, instead of proceeding with a gradual and continual enlargement, suddenly rising at certain stated periods from their embryo state, and enlarging and pushing up through the gums, when it becomes fit that the child should take more solid food than the mother's milk. So the second set of teeth, in a more particular manner, lie quite stationary in their growth within their little sacs, yet quickly, at stated periods, they increase,

* I have shown that the tortuous arteries always form a provision for the occasional increase of the action and acceleration of the blood.

the enamel is formed, and they rise above the gum. There is an infinite number of such changes depending upon the same laws of the economy, and not different from those which control the growth, and direct the shape of parts. They depend upon certain laws of the constitution, which give an excitement to certain parts, at stated periods, and which no theory partially applicable will explain. There is a series in which the parts of an animal body are matured, and a succession in which the functions are brought to maturity; and in the female constitution, there are laws determining an action upon the womb and breasts, and all parts subservient to conception and the nourishment of a fœtus, at that period when the woman is arrived at the age fit to take upon her the part of a mother.

OF MENSTRUATION.

Under this head, I shall confine myself to such a general view of the subject as is necessarily connected with the peculiar functions we are now endeavouring to comprehend.

Menstruation is a state of preparation for conception. When, therefore, the menses flow at the natural periods, and in due quantity, it is a sign that the woman may conceive, and that her system is fit for the support and nourishment of the child. It is a general affection of the system, which has a tendency to relieve itself by a topical action, by the excited action of the uterine system; and this excitement of the uterine system is the end which nature is accomplishing. To explain this, I may be allowed to take a short preliminary view: each particular organ or viscus, whilst it has its connections with the general system, is, in truth, a system within itself, having its peculiar functions, sympathies, and even vascular action, in a certain degree independently.

Were not this, in some measure, the case, we should see no local disease or topical action; and no vascular action could be for a moment stationary and confined to one part. The body would, indeed, be then only one great hydraulic machine. But while the several parts have the property of being excited separately to an accelerated action, they are actuated by remote sympathies, and by these sympathies and relations is the whole system in a great measure supported.

Before menstruation commences, there is a preceding indisposition, and symptoms indicating a constitutional affection. And these complaints are usually more severe in the first than in the subsequent periods. The general revolution in the system begins to accumulate its action towards the womb, and those symptoms usually accompanying uterine irritation show how far it is affected, and in a little time the menses flow. Now, I conceive the flow of the menstrual blood to be, not the end which nature is here labouring to accomplish, but the means of allaying the excited state of the uterine system, after the object is accomplished. It is not the discharge of a few ounces of blood which relieves the system; for drawing blood simply will not do it; but it is the excited action of the uterine system which relieves the general distress, and that topical action has full relief in the menstrual dis-

charge. General and topical plethora are terms which have been of great service in explaining this periodical change in the female system; but the state of mere fulness has little effect either on the constitutional or topical change. Even in the exhausted and debilitated state of the system, when menstruation ceases from the want of energy and power in the vascular system, still there remain the same laws governing the sympathies and relations of the several parts; and, although they are feebly and imperfectly excited, they give rise to accumulated distress at the period in which the menses should flow.

With regard to vicarious hæmorrhage from remote parts of the body, some, whose opinion I greatly value, do not consider them as deviations of the menses. At all events, from what I have seen of such hæmorrhages, (tumours, for example, discharging blood at the menstrual periods,) I would observe, that there is an excitement, throbbing, and distention, previous to the discharge of blood, which confirms me in the notion of the necessity of a counter excitement and action, as well as the discharge of blood, being necessary to make a derivation from the uterine vessels. It is by dissection alone that we can form a correct opinion regarding the final use of the periodical return of the menses.

By dissection we come to the knowledge of the most essential facts. In the first place, it is found, that the ovaria, and their vessels, partaking of the general excitement of the spermatic arteries, are enlarged, full of blood, and with every sign of increased action. We find, also, that the ova are matured and brought to pullulate, and almost to start from their investing membranes. Unless the ovaria are in this state of preparation, conception cannot take place. In considering this subject of menstruation, the mere circumstance of the discharge of blood has been too much thought of, while the other more essential circumstance, the change upon the ovaria, has been neglected. The end of this periodical excitement is to ripen the ovum, the flow of menstrual blood to allay the excited state of the uterine vessels. Accordingly, if conception should take place, the excitement proceeds, and no flow of secreted blood takes place during the period of gestation.

It is not easy to determine, says Haller, either in this or in any other spontaneous hæmorrhage, from what kind of vessels the blood flows. From the circumstance of the hæmorrhoidal discharge, which certainly is from veins, and from the lochia, which is generally supposed to be a discharge from the venous sinuses of the womb after delivery, we have the argument of analogy, that in menstruation also it is a venous discharge. This opinion is further confirmed from stagnant blood being found in the uterine veins of women dying during the flow of the menses, and orifices being observed larger than could well be supposed to be the extremities of arteries.

It is little probable that spontaneous hæmorrhage proceeds from the rupture of the extreme arteries, because it is the activity of the arteries which causes the hæmorrhage; and because this activity is the exertion of a muscular force, and the exertion of a muscular fibre never is such as to tear the fibre itself. On the other hand, we observe that it is the necessary consequence of an increase of the action

of arteries, that the corresponding veins dilate, and seem to suffer a force of distention proportioned to their increased activity. We must not forget that many are of opinion, that the menstrual blood flows from the exhaling arteries. This opinion must rest upon argument, and not facts, unless the assertion of Rauw be taken as proof, that he could distinguish their mouths; or that of Meibomius, who said he introduced bristles into them. That anatomists have introduced bristles into pores, or foramina, it would be ungracious to doubt, but that these were the orifices of exhaling arteries, is difficult to believe. I rather imagine, that there is a provision for this evacuation in pores, or foramina, in the extreme veins on the vascular inner surface of the womb.

From the consideration of the cause of menstruation, as I have conceived it, from the symptoms which precede and accompany it, and from the effect attributable to the menstrual action on the uterine system, we cannot consider it as a mere evacuation of blood, but rather as of the nature of a critical discharge relieving the symptoms which preceded it. With regard to the opinion of its being a secretion, we must first know accurately what is meant by the term. If those who suppose the menstrual blood a secretion, mean only that the blood is changed by the action of the vessels of the womb, I should willingly acquiesce in their opinion; for even during the bleeding from the arm by the lancet, or from a common wound, the blood is altered in the space of the few minutes during which it flows; and before the final stopping of a common hæmorrhage, there is a change in the properties of the effused blood.

When there is an unusual source of irritation in the womb, added to the natural and periodical excitement of the parts, the menses become more profuse, they last for a longer period, the time of their intermission is shortened, and, in the end, from some diseases of the womb, there is a perpetual oozing of the blood, which debilitates the woman, and destroys her constitution, or there is sudden and profuse discharge with coagula, unlike the usual evacuation.

OF THE CHANGE PRODUCED BY THE UNION OF THE SEXES.

In considering those changes produced on the ovaria and womb by impregnation, we must have recourse to analogy in the first instance. By attending to the changes produced in vegetables, and the lower animals, we may be enabled to comprehend some of the changes in the female organs consequent upon conception, which we might not otherwise be enabled to understand.

We see that vegetables propagate their branches in every respect like the parent trunk. We see in the autumn the bud lodged in the axilla of the leaf, and observe it pass through the winter in a kind of dormant state; but when it is influenced by the returning heat of the spring, it shoots out to full maturity. This growth is a natural power of propagation and increase, marked by no very peculiar circumstances, yet bearing a strong analogy to the production of the seed.

In the formation of the fruit of the same tree, we see a more com-

plicated provision for the propagation of the plant. We find that although the seed appears to be formed by the natural growth of the part like the bud, yet before it becomes prolific, and capable of growing, and arriving at maturity, it must be influenced by circumstances similar to the union of the sexes of animals; that its power of reproduction depends upon the reciprocal action betwixt the parts of the same plant, or by the approximation of male and female plants.

Between the formation, maturity, and impregnation of the seed of plants, and those of the ova of animals, there is a close analogy. The seed is formed and matured while attached to the parent plant; but the vessels of the plant having completed this operation, shrink from their connections with the seed, leaving it with its little system of vessels complete, and with a kind of imperfect life, which may be considered as analogous to a dormant state. This imperfect life, or perhaps a state merely capable of being excited into life and motion, continues for the winter season, or for a longer period.

The flower of plants solicits the fluids to the seed, as the influence of the leaf cherishes the bud in the axilla. The pulp of the fruit is probably a provision of the same kind, or when it has fallen, to lay the foundation, by its decay, of a soil suited to the tender plant.

In the seed itself, we have much to admire. We find it incased in a strong husk, or shell, which is in general provided with a porous part ready to imbibe the moisture of the ground. In the nut within the outer shell there is a soft spongy substance, which, receiving the moisture, swells and bursts up the shell, and relieves the seed. The kernel of the nut is then like a common seed, it has begun to vegetate, and these are the parts which form the system of its economy. The principal part of the seed consists of albuminous matter for the supply of the nourishment to the embryo plant, so as to prolong its shoots, and to send down its roots into the earth. The little embryo plant lies complete in all its parts, betwixt the lobes of albuminous matter, in a state of torpor, or in which the operation of the living principle is suspended. From the embryo plant there extends into the albuminous matter of the seed-vessels, or tubes, inactive, but ready, on the supply of heat and moisture, to absorb the nutritious matter of the albumen, and minister to the increase of the embryo plant.

Now the root of the little plant sprouts from the seed, and has a tendency to strike into the ground, and the bud rises to the surface towards the light, and the influence of the atmosphere.

We see in this instance, that the operation of the system of tubes of the embryo plant in the albumen was merely suspended, that upon the seed being put into the ground, the heat and moisture promote the germination, and the nutritious matter of the albumen is carried to the embryo plant. In the first stage of this change, the matter absorbed by the vessels of the albumen supply that nourishment, which afterwards is conveyed from the root striking into the earth, and also what is supplied from the leaves absorbing from the atmosphere. And when the roots have struck into the earth, and the first leaves rise upon the surface, the lobes of the albumen are exhausted and fade, or rise up in the form of leaves, still cherishing the tender plants.

When we come accurately to examine the situation of the embryo in oviparous animals, we shall find the same provision for the nourishment and growth of the young animals, independent of external circumstances, the nourishment being prepared for it until it shall be enabled to gain strength to feed itself.

The manner in which an egg is formed is this :—The yolk, with its delicate membranes, is formed in the ovarium of the hen. The ovarium is placed on the back-bone ; innumerable yolks are seen gradually formed, and successively increasing in size. When they are matured, they are of the full size, and such as we see them in the perfect egg : they are surrounded with a delicate web of membranes, extremely vascular ; the membrane of the yolk bursts when it is mature and impregnated, and then it falls into, or is grasped by the infundibulum, or what answers to the Fallopian tubes in woman and mammalia. While yet in the egg-bed, the embryo is seen to be included in its membranes, upon the surface, or in the membrane, of the yolk : it is called cicatricula ; as the yolk and the cicatricula pass through the uterus, the yolk, in a most curious way, has the addition of the other part of the egg. The uterus of a bird is not like that of quadrupeds or viviparous animals, simply for the reception of the ovum ; but it is long and convoluted like the intestines. And the yolk, as it drops into the upper part of it, collects as it passes along the uterus, the white of the egg, which is a secretion from the uterus. As it proceeds downwards, it receives the membranes of the white, and before it is excluded, it is coated with the shell to preserve it from injury when it shall be dropped from the hen. In the fully formed and incubated egg this is the situation of the parts. Under the shell is a membrane which invests the whole parts, but leaves a space containing air in the greater end betwixt it and the shell. Within this membrane the glairy white of the egg is contained, and within the white or albuminous matter is the yolk. Under the membrane of the yolk there is a small spot of a lighter yellow than the yolk. This, upon examination, is found to be a vesicle, and within it we see a lesser circle formed by an inner vesicle : this is the cicatricula, and within this inner membrane the rudiments of the chick are contained. We may observe, that the yolk is specifically lighter than the white ; and that it is fixed towards the two extremities of the egg, to the albumen, or white, by the chalaza. These are like twisted cords, which arise from the yolk, and expand in the white, so that they take a pretty firm hold on its tenacious substance. These chalaza are not fixed to the yolk in its axis, but to the side, so that the buoyancy of the yolk keeps it revolving as the egg is turned, so as always to present the cicatricula to the upper part of the egg, in whatever way it is placed ; consequently it is always contiguous to the body of the hen, so as immediately to receive the influence of the maternal heat. By incubations the principle of life in the chick and its membrane, is roused, and the first perceptible change appears in little bloody streaks, which, running together, form a circle of vessels, and which are seen to terminate in the umbilicus of the chick.

This vascular circle, the most beautiful appearance of any in the

economy of animals, ought to be particularly explained. In Mr. Hunter's book, treating of the blood, there is a plate which represents the embryo of the chick in the incubated egg, at three different stages of its formation, begining with the earliest visible appearance of distinct organization. The preparations from which these figures are taken form part of a complete series contained in Mr. Hunter's collection of comparative anatomy. They are meant to illustrate two positions laid down in his work, viz. that the blood is formed before the vessels, and when coagulated, the vessels appear to rise; that when new vessels are produced in a part, they are not always elongations from the original ones, but vessels newly formed, which afterwards open a communication with the original.

This to me seems an idea founded on a very limited view of the state of the parts. We must recollect that this is not the formation of new parts or new vessels. The embryo is in that state of which I have endeavoured to convey an idea, by the term dormant: possessing that degree of life which is to be renewed by incubation, or artificial heat, but which will last a great length of time, and, like the germ in plants, be brought to vegetate only in particular circumstances. The tract of these vessels is laid in the original conformation of the embryo and surrounding membranes: they are now merely called into action, and we see only the effect of this action. We see red blood formed; we know that the redness of the blood is derived from the membranes, and matter which surround the embryo, and that it is conveyed to the chick or embryo. Before we allow ourselves to conjecture what is the first motion in the circle of actions which now take place, we must consider whether it be not more likely that the first action of these vessels is in absorption? that is, an absorption in the extremities of these vessels, or is there first an action of the heart of the chick? We are left to this question. Is it probable that a change shall take place in the fluids which shall stimulate the vessels? or shall the heat of incubation stimulate the vessels to act upon the contained fluids? or, as seems most probable, does the incubation, at the same time, produce a change in the fluids, and stimulat the vessels to action? To explain my opinion, I shall describe the probable series of actions.

In common seed, the small germ of the plant has its vessels passing out into the lobes of the albumen to absorb the food, whenever the peculiar circumstances necessary to its activity shall arrive. We have to observe, that where the nut was attached in its husk to the tree, it has left a porous part; by this cribriform kind of plate the moisture of the earth enters;—that dry scurfy substance which we observe on the inside of the shell swells with the moisture, which also penetrates the albumen or kernel—the moisture forming a combination with the albumen prepares it for absorption; the vessels are at the same time excited, absorb, and thus nutritious fluids are conveyed to the germ—the nut splits by the swelling of the parts, and the corculum or bud sprouts up. We find, then, that in this instance the grain, or nut, is brought into action by the fluids absorbed, forming new combinations with the albumen or kernel, and the active exertion of the living powers, beginning by an operation in the fluids.

In the same manner, I conceive, that the incubation of the egg causes an action first in the fluids, not in the solids (for these are solids according to the strictest signification of the term; and strong membranes, as a little vinegar will show, when poured upon the albuminous substance of the egg.) A change takes place in the fluids: there are new arrangements suiting them for absorption; and they are absorbed by that circle of vessels which is laid on the original formation of the membrane. The fluids act as a stimulus to those vessels, whose alternate action and relaxation commence, and never cease until the termination of life. I conceive this explanation, which I have offered, to be more consonant with the great principles of physiology, and an extensive analogy of similar actions in the economy, than that explanation of Mr. Hunter, which supposes the specks seen at the sides of the vessels to be spots of coagulated blood, destined afterwards to become blood-vessels. For I am apt to conceive the red blood to be formed only after several rounds of the circulation, and to depend upon a more perfect assimilation than that first excited; and that Mr. Hunter is all along in this mistake, that he is supposing these vessels to be newly formed, which are laid in the constitution of the membranes surrounding the embryo, and which are now only called into action, and only become apparent when they convey red blood.

In the system of the egg there are other circumstances worthy of notice: as the chick grows by the absorption of the white, or albumen, the new combinations reduce to a lesser bulk the whole mass, which is within the shell, and now we perceive the use of the air-cell, which, enlarging, fills up this space. When the chick has escaped from the shell, the yolk of the egg is not exhausted, but it is found to be received into the belly of the chicken, and to have a conduit leading into the duodenum, by which its nutritious matter is poured into the intestinal canal. It is for some time a source of supply to the young animal until its strength is equal to the digestion of its appropriate food. And in this respect it is analogous to the suckling of viviparous animals.

Let us now observe what analogy exists betwixt the generation, or rather the birth and nourishment, of the embryo of the viviparous animal, and those of the oviparous. As to the precise effect which the approach of the male has upon the ovarium of the female, whether by this union of the sexes there is an actual addition to the ovum, or only an influence exerted on the parts already there by the presence of the male semen, it seems almost needless to hope for an absolute decision.

The resemblance of the offspring to both parents would influence us at once to conclude, that there must be a union of the parts from both sexes. But when we consider how much the peculiarities of individual animals depend upon certain peculiarities of action; how the constitutional predispositions must depend on the same peculiarity in the action of the vessels, since the doctrine of absorption teaches us, that of actual substance nothing is permanent, but all suffers an incessant revolution and change, we are forced to conclude, that nothing can remain but certain peculiarities of action, and we may then come to believe, that the male semen merely influences the state of the parts already formed, and does not bestow an actual substance.

In the speculations on the subject of generation, facts and observa-

tions have been so very rarely attended to, that those which have been offered seem to have had an influence beyond their real value. Thus the microscopical demonstration of animalculæ swimming in the semen of the male has given birth to an idea that they were homunculi, which being introduced into the proper nidus of the female, became the human fœtus. Though, where all is conjecture, and, perhaps, no better explanation is to be offered, it may seem improper so directly to contradict any theory, still I must say, that this is, in my mind, the height of absurdity. To suppose an animal secreted along with the seminal fluid from the testicle of the male, (which, in all probability, is the production of stagnation and putridity,) swimming and nourished in the male semen, and yet to hold, that on being introduced into the ovaria it changes from an active animal into an impalpable gelatinous-like mass, and after a series of changes grows at last to the maturity of a human being, is altogether beyond comprehension.

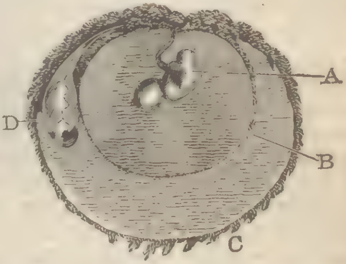
The experiments made by the ingenious Dr. Haighton, throw considerable light upon these delusive speculations regarding the impregnation of the female. He found by experiments on rabbits, that upon cutting the Fallopian tubes, forty-eight hours after the coitus, the impregnation was equally obstructed as when he had cut them previous to admitting the male: it would appear that in these animals impregnation is by no means the instantaneous effect of the union of the male and female, but that it requires at least fifty hours; for when Dr. Haighton cut the Fallopian tubes at that period, it did not prevent impregnation. Dr. Haighton proves, that the generative process is not an instantaneous operation, as we should very naturally suppose, but an operation requiring time. That the semen does not reach the ovaria during, or immediately after, the coitus, is sufficiently evident; and it is still more so that the ovum is impregnated while in the ovarium, and not upon its descent into the womb, which is proved from the fœtus sometimes remaining in the ovarium, or tubes, and growing to maturity. Dr. Haighton supposes the semen only to affect the vagina and uterus, and that a consent of parts, or sympathy, is communicated along the tubes and ovary to the ovum; and that neither the semen nor the aura seminalis reaches the ovaria. When we look abroad for analogies, however, and find the semen of some animals, as fishes, merely thrown out upon the already evacuated spawn, we cannot readily acquiesce in this opinion of the mere sympathy of the female parts calling the young animal into life.

Leaving this subject, we have to observe, that previous to impregnation there is a ripeness and prominence of some of the ova, that by coition the Fallopian tubes do not instantly grasp, impregnate, and cause the bursting of the ovum from the ovarium; but there is an action commenced which gradually brings about this change. Whilst the ovary is thus affected, the tubes are preparing for their action of embracing the ovum; there is an increased turgescence in their vessels, and an enlargement and swelling of the fimbriated extremity. When thus prepared, it approaches the ovarium, grasps and receives the ovum; and by a peristaltic motion, probably very slow and gradual, the ovum is conveyed into the cavity of the uterus.

OF THE OVUM, AND ITS CONNECTIONS WITH THE UTERUS IN THE EARLY MONTHS OF PREGNANCY.

The ovum, when it has descended into the uterus, and is perfect in its structure, is a soft oval mass, fringed with vessels, and composed of membranes containing the early fœtus. When opened, or dissected, it presents three cavities, or we observe the fœtus to be surrounded with three distinct membranes :—1. The decidua, or tunica filamentosa, false chorion, or spongy chorion :—2. the chorion :—3. the amnios. Of these coats, the outer one is formed by the womb, the others constitute the ovum, as it has descended from the ovarium. We shall, in the first place, attend to the original membranes and general constitution of the ovum, and then to the deciduous covering which it receives in the womb.*

PLAN OF THE MEMBRANES.



A, the Fœtus ; B, the Amnios ; C, the Chorion ; D, the Vesicula Alba.

Amnios.—The amnios is the vesicle which immediately involves the fœtus. It is a very thin and pellucid membrane in the early state of pregnancy, but it acquires considerable thickness and strength in the latter months.

The amnios contains a thin watery fluid, in which the fœtus is suspended. In the absorption of the early months we find the quantity of this fluid very great, in proportion to the whole ovum, and this forms a defence to the delicate and almost gelatinous substance of the fœtus, while it is a provision also for the regular presentation of the head of the child ; for now the fœtus being suspended in this fluid, and hanging by the umbilicus, and the head and upper part of the body greatly preponderating, it takes that position, with the head presenting to the orifice of the womb, which is necessary to natural and safe labour, the fœtus being prevented from shifting in the latter months by the closer embracing of the child by the uterus.

Chorion.—The chorion is the second involving membrane of the fœtus : on the inside it is smooth, and betwixt it and the amnios a gelatinous fluid is interposed. In the early months it is much stronger than the amnios, but in the advanced stage it has come in contact with the amnios, no fluid being betwixt them. And in proportion as the amnios gains strength to be of essential service in dilating the orifice of the

* See Albin. Ann. Acad. lib. i. cap. xviii. and xix. Hunter's tables of the Gravid Uterus.—Camper Icones.

womb during labour, the chorion has relatively become very thin and weak. On the outside the chorion is shaggy and vascular, and constitutes those minute extremities of the vascular system of the ovum, which attach to the surface of the womb, or rather to the flocculent membrane which it throws out.

The UMBILICAL CORD.—When we can first discern the fœtus, it is merely like an opaque oval body of the size of a common fly, and closely attached to the amnios; but by degrees it recedes from it, and then we perceive that it is attached by the umbilical chord, which consists of the trunk of the vessels going out from the fœtus, and which, distributed upon the chorion, receives the supplies from the maternal system.

Now we perceive that the fœtal system which descends from the ovarium is not merely a fœtus or embryo, but that this embryo, besides a system of vessels within its own body, is surrounded completely with membranes, and that from the vascular system of the embryo there go out vessels, which being minutely distributed to the outer vesicle, or membrane, and actuated by the same heart which circulates the blood through it, our little corporeal system prepares for imbibing the due nourishment from the uterus.

VESICULA ALBA.—The vesicula alba, or umbilicalis, is a little vesicle which lies betwixt the chorion and amnios: it contains a white fluid; it is connected with the navel or cord, by an artery or vein. Very little has been offered as explanatory of its use: it has been considered as similar to the alantoes of quadrupeds, and having a connection with the urachus; but it has no communication with the bladder, and soon disappears. Whereas, if it had been for receiving the secretion of urine, it would have been prepared for the more mature state of the fœtus.

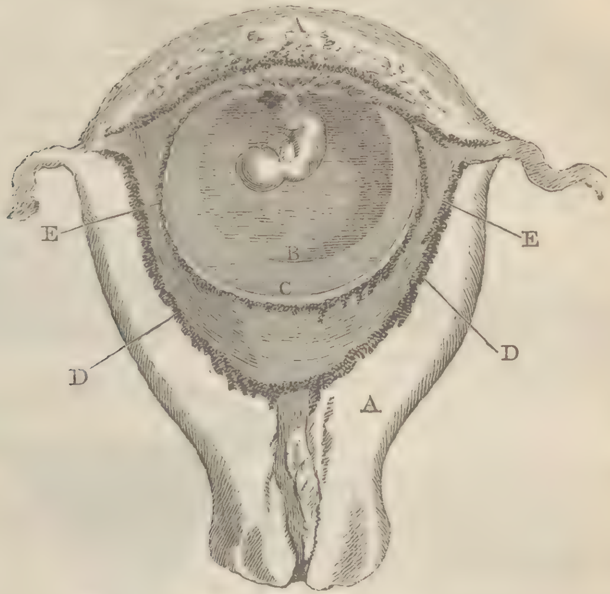
I conceive it not to be improbable, that it is a provision of supply for the embryo, previous to its perfect attachment to the uterine system, and during its descent into the womb, perhaps similar to the albumen of oviparous animals, but which, after the perfect establishment of the connection betwixt the fœtal and maternal system, shrinks and disappears, as being no longer necessary.

OF THE ADDITIONAL MEMBRANES WHICH THE OVUM RECEIVES FROM THE UTERUS.

While the ovum is taking the changes consequent upon impregnation, the womb partaking of the general sympathy which prevails over the whole uterine system, suffers a change adapting it for the reception of the ovum. The first appearance of action in the womb is marked by a greater activity of the vessels, a swelling and softness of its substance. While on the inner surface there is an exudation, which, being converted into a spongy membrane, is peculiarly adapted for the reception and adhesion of the ragged and vascular surface of the ovum.

In the following plan we shall be able to observe the relations and inflections of the uterine membranes or decidua, as seen and described by Dr. Hunter, and of their correctness my observations in dissection leave no doubt in my mind. AA, the uterus in outline; B, the amnios with the fœtus; C, the chorion. Now it is observed, upon a careful examination of an abortion of the early months, that besides the chorion and

amnios, there is a spongy membrane, of two distinct laminæ which invests the chorion. The outermost of these is found to surround the whole ovum, even investing that part which has become the placenta



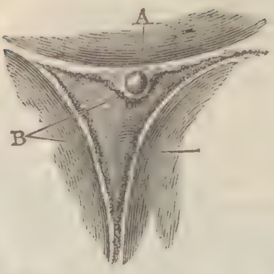
by the accumulation of vessels. This outer membrane, then, may be represented by the line DD. It is represented as adhering to the surface of the womb, as it must do in fact. We observe, again, that it is perforated where the Fallopian tube enters the womb; that at this part it is not formed; so that, according to Dr. Hunter, and the preparations which I possess, these tubes open into its inside.

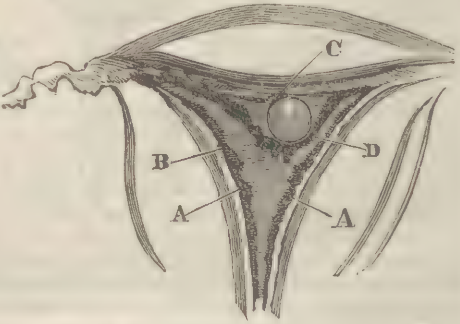
Upon dissecting up the outer lamina of the decidua, we find that where the placenta commences, it is reflected over the surface of the ovum and the shaggy chorion of the ovum, so as to be represented by the letters EE. We shall now understand the distinction betwixt the Decidua Vera DD, and the *Decidua Reflexa* EE.

It would appear that this membrane is either completely formed, or at least the fluid which is to form it is thrown out previously to the descent of the ovum: indeed, so intimate is the sympathy betwixt the whole uterine system, that this membrane is formed in those cases where the ovum does not descend, but constitutes the extra-uterine conception.

Dr. Hunter supposed, that the ovum passed into the cavity of the uterus, whilst the coagulable lymph was pouring out by the arteries of the uterus, and that it was thus immersed in and surrounded by the decidua; for he could not conceive that it could gain admission betwixt the lamina of the membrane already formed.

The only other supposition is, that the ovum A, upon its descent, gets entangled behind the deciduous membrane B, by which means the ovum is not left loose in the cavity of the womb, but it is soon attached and surrounded with a membrane, or vascular web, from which it can immediately draw supplies, and by this provision also its adhesion to the superior part of the uterus is ensured. But as the same action of the uterus continues, and, as we must naturally suppose, is rather excited by the presence of the ovum in its cavity, the surface of the uterus at A continues to throw out a coagulable matter which surrounds that part of the ovum, so that this will immediately become its situation.





A, The *decidua vera*, formed before the descent of the ovum; B, the *decidua reflexa*, formed by the ovum getting behind it and pushing it down; C, the efflorescence formed by the coagulable lymph which was poured out after the descent of the ovum, which, being interposed betwixt the ovum and uterus, will form the uterine portion of the placenta.

OF THE PLACENTA, AND OF THE NUTRITION OF THE FŒTUS.

When the ovum first descends into the uterus, the fleecy surface of the chorion establishes a universal adhesion; but no sooner is the attachment of the ovum confirmed, than the vessels of the fœtus, which are universally distributed over its surface, begin to accumulate to that point from which the more abundant supply is obtained. Thus, from the universal adhesion, the vessels of the fœtus are massed and accumulated together, so as to form a thick cake or placenta. This takes place upon the same principle that the roots of a plant stretched towards the soil best suited to it, or the branches and leaves of a plant grow and spread towards the light. The placenta is destined to adhere to the fundus of the womb, and there we observe the accumulation of the large vessels of the womb, it being equidistant from the several sources of blood; and to this point is the tendency of the vessels of the chorion so great, that we sometimes see the vessels of the cord running three or

four inches upon the membranes before they reach the placenta, evidently showing that the point to which the umbilical cord had been originally attached was not opposite to the more vascular part of the womb; but that the vessels had to stretch and elongate some way from the insertion before they accumulate in form of the placenta, towards that part of the uterus where there was the greatest vascularity.

But the formation of the placenta on the fundus of the womb is not constant, although there are many provisions for insuring attachment there. But when it does form low in the womb, or on the orifice itself, we then perceive the reason of nature's solicitous care in preventing it; for it occasions the most dangerous floodings from the placenta presenting on the approach of labour, and its connections being necessarily torn up previous to the delivery of the child.

The placenta of the advanced stage of gestation is a mass formed partly by the accumulations of the vessels of the fœtus (the trunk of which is the umbilical cord), and partly of a vascular and cellular portion formed by the uterus. On the surface attached to the womb, the placenta exhibits deep and irregular fissures which divide it into lobes. The inner surface is smooth from the investing membranes, but raised into irregularities by the numerous and tortuous ramifications of the umbilical vessels. When rudely torn or cut into, it appears to be a spongy substance, formed in a great part of an irregular tissue of vessels and cellular substance.

In the human subject we find, that the maternal part of the placenta is thrown off with the other secundines, and does not separate from the fœtal part of it. While, in other viviparous animals, the monkey excepted, the filamentous extremities of the fœtal vessels separate from the mass formed by the maternal vessels of the uterus.

The placentary vessels of the fœtus never touch the surface of the womb, but communicate with the maternal system through the vessels of the womb, which pierce the deciduous membrane. Still the question of the precise manner in which the vessels of the fœtus communicate with those of the mother remains undetermined. I conceive that in the early stage the deciduous membrane being thrown out by the action of the uterine vessels, those of the chorion stretch into it, and absorb the nourishment. The decidua is a vascular membrane, but it has, at the same time, a peculiar spongy texture. This spongy or reticulated structure of lamina of the decidua ceases where the placenta is affixed. When we carefully dissect up the decidua to the margin of the placenta, it is found to be more rigid, white, firm, and thick.* When we examine the outside of an entire ovum, we observe, that at the place covering the placenta it is corrugated and full of irregular eminences like the convolutions of the brain, and amongst those irregularities many small convoluted arteries may be discerned, with spots of extravasation and the flat mouths of veins. Upon dissecting up this maternal part of the placenta, we find it to form the firmest part of it; and by the difference of colour, as well as by the possibility of tearing it up, or dissecting from the mass of vessels of the chorion, we recognise it as the decidua. This union, however, betwixt the maternal and fœtal parts of the placenta is inti-

* I speak after dissecting the ovum of the third month.

mate; and it is impossible to determine by dissection with the knife, whether there be inosculations betwixt the maternal and fœtal vessels, or whether the nourishment of the fœtus is by absorption; nor can we distinguish in the first months the cellular intertexture which may be observed in the placenta of the full time, as described by Mr. Hunter.

In explanation of this part of our subject, I have purposely dissected, and made drawings of the ovum in several stages.

OF THE LIQUOR AMNII, AS CONDUCING TO THE NOURISHMENT OF THE FŒTUS.

Some physiologists, observing the analogy which exists between the function of the placenta and the lungs of breathing animals, have conceived that the liquor amnii is the source of nourishment, and that it is taken into the stomach. I believe they have conceived some analogy to exist betwixt the albumen of the egg and the liquor amnii, which in their minds has strengthened this opinion. But there is here no analogy: we have seen, that the embryo of oviparous animals being formed with the yolk in the egg-bed or ovarium, descends into the uterus, and there receives the addition of the albumen or white. On the other hand we find that the ovum of viviparous animals is formed in the ovarium; and that the liquor amnii being within the membranes of the ovum, must be the production of the fœtal system. Further, when the ovum has descended into the womb, and grown to some maturity, we see that there is no connection by vessels betwixt the fœtus and mother, but through the placenta; that the liquor amnii is within the involving membranes of the fœtus, and that, consequently, it must be thrown out by the vessels of the fœtal system. Thus, to suppose the fœtus to be fed by the liquor amnii, would be to suppose it to draw resources from its own system, and that the vessels poured out a fluid, which is afterwards to be taken into the stomach.* But without adducing arguments, it is sufficient to say, that fœtuses have been brought forth, monstrous in their conformation, and without mouths, yet well grown.

Of the placenta as the source of nourishment to the fœtus.—When we consider the mere speck of the embryo in the first weeks, we see that it can have no other source of nourishment than through the extreme vessels of the chorion, connected with the short umbilical cord; and we may be convinced, also, that in its progress to maturity, when the general connections of the chorion cease, and the placenta is formed, the sole supply is through its vessels. Regarding the manner of the communication betwixt the vessels of the mother and child, there are many opinions. The simplest explanation, but the farthest from the truth, is, that the arteries of the womb are continued into the veins of the fœtal portion of the placenta. That, on the other hand, the arteries of the fœtal system are continued into or inosculate with the veins of the womb; and that thus the blood of the mother's system is carried by direct inosculation.

* A greater absurdity than that of which a foreign author is guilty cannot be imagined; because the liquor amnii, or some fluid, is found in the trachea, he supposes that a fœtus respires, and receives oxygenation from the liquor amnii.

A little investigation will convince us, that this is a very unlikely conjecture. We see the embryo surrounded with its vessels, and forming a complete system within itself, descend into the womb. We see that the attachment betwixt the surface of the ovum and the womb depends on a reciprocal action between them; and when the fœtus is feeble, or diseased, or when it dies, the uterus immediately separates from it, as from a dead part, and there is an abortion. Again, it is not natural to suppose, that the circulating fluids of the adult are calculated for the circulation in the embryo, or that the blood of the adult is fit for the circulation of the fœtus. When we inject the vessels of the fœtus, we find the veins and arteries of the umbilical cord to inosculate freely with each other, and the fluid passes from the arteries to the veins with little extravasation or escape of fluid, and such only as may be supposed to pass from torn vessels. Again, the bleeding of the child does not draw from the maternal system; for example, when the accoucheur has to perform the operation of embryoulcio, and when the arteries of the brain pour out their blood, the woman does not suffer, nor is there any danger of hæmorrhage from the cord after the delivery of the child. Again, what does the analogy of other animals show us? We may observe, in the first place, that, probably on account of the peculiar form of the womb of woman, and in these circumstances to guard her from danger of hæmorrhage during delivery, it is necessary that the placenta should be accumulated towards the fundus of the womb. Now, to allow less danger of the separation of the secundines from the womb, and consequent abortion, there follows a necessity for the human placenta being attached in a particuliar manner; and in place of the maternal part of the placenta remaining with the womb, as in other animals, the whole mass separates on the delivery of the child. The necessity for this firmer attachment of the human placenta causes the connection betwixt the fœtal and the maternal portions to be very intimate, and the manner of the vascular connection by no means easily demonstrated.

In other animals, however, for example, in those which have the small and numerous placenta, or cotyledons, the fœtal and maternal portions of the placenta separate easily; the maternal part being a prominent vascular bed, which is a part of the womb, and is not deciduous. Here we find, that the glandular-like portion which belongs to the womb may be minutely injected, and no particle of colour pass into the fœtal part; and again, injection shows the fœtal portion to be merely composed of the fleecy extremities of vessels, which, however minutely injected, do not show any inosculations with the maternal vessels; in short, here the connection betwixt the extremities of the two systems is so very loose, and the filaments so minute, that we can imagine no other kind of connection, than that the extremities of the umbilical vessels take up by absorption the nutritious matter necessary for the system of the child, and that this is secreted by the vessels of the womb.

Investigation in every department of natural history shows a similarity and a simplicity in the operations of nature. Comparative anatomy may be brought with much advantage in illustration of the very obscure laws which guide the functions of the parts of generation. When we turn our attention to the egg, we find, in the first place, that the vascular system is complete within itself, and requires no permanent connection with

the maternal system to invigorate its action. We find that the artery which passes out of the umbilical cord of the chick, and which is distributed to the membranes of the white, pulsates strongly, and carries venous-coloured blood. We find the returning vein carrying arterial-coloured blood. We find, then, that these vessels must have a double function: they imbibe the nourishment from the white, and convey it to the increase of the chick; and they at the same time perform an action similar to that of the pulmonary vessels of the adult, seeing that they carry out dark-coloured blood, and convey it back to the chick, of a bright vermilion colour. Now, I do not conceive that this change upon the blood is performed by the communication of the atmosphere through the shell, for I see no distinction in the colour of the vessels, which are contiguous to the membrane of the shell, and those which are removed from it by the expanding of the air-cell. Further, we find that there is an intermediate kind of generation in fishes which are oviparous, but retain the egg within their womb, until the fœtus is matured: here no communication with the air or water can be allowed.

Since we see that the chick in ovo is capable of ministering in every essential particular to its own increase, wherefore should we suppose that the fœtus of viviparous animals has any other more particular connection with the womb of the mother?—The difference is, in my mind, this simply; the ovum of the oviparous animals descending through the convoluted and intestinal-like uterus of the hen, accumulates a quantity of matter around it, which serves every purpose of nutrition when the embryo shall be finally separated from the maternal system; but in the viviparous animals the ovum descending into the womb, remains there, and has a continual supply of nutritious fluid, secreted from the vessels of the womb, as it is required by the fœtal system. As in the egg, the membranes surrounding the white have the same effect upon the blood, which is afterwards produced by the lungs; so has the placenta of viviparous animals the double function of supplying nourishment, and the purifying of their blood. The umbilical vein carries back pure arterial blood, and the common opinion is, that the blood of the fœtus coming in contact with the blood of the maternal system, receives the principle from it, which bestows this quality of colour, with other necessary qualities, of which this of colour is but the sign to our observation; or we may say that the carbon of the fœtal blood is imbibed by the maternal blood; and in this way the blood of the fœtus is purified. It is not necessary to this change, on the fœtal blood, that it should come in immediate contact with the maternal blood, for it is possible, that the matter thrown out by the maternal vessels, whilst it is nutritious, has also in it, in a condensed and not a gaseous form, that which is essential to the change of the blood of the fœtus from the modena colour to bright vermilion.

OF THE EXTRA-UTERINE CONCEPTION.

We find some curious facts relating to the action and sympathy amongst the parts of generation, proved by the cases of extra-uterine conception, where nature, baulked and interrupted in her usual course of operation, shows unusual resources. It would appear, that the ovum, after impregnation, has, in some cases, remained attached to its original

seat in the ovarium, perhaps owing to some want of due sympathy, and synchronous action of the Fallopian tubes, which should grasp and receive the ovum. In other instances the ovum has been received into the Fallopian tubes; but either from a want of sufficient dilatation and action in them, they have not been able to propel it forward, or the ovum, taking upon it that action which is destined to form its connections with the uterus, adheres, and is enlarged in the tube, so that it cannot be conveyed down into the womb.

I am not so fully satisfied of that kind of extra-uterine conception, where, after impregnation, the ovum has dropped from the ovarium, and lies in the cavity of the abdomen amongst the viscera. Here it is supposed the vessels of the fleecy chorion spread, and attach themselves to the surface of the viscera. I believe that the cause of the extra-uterine conception is previous adhesion, which prevents the action of the Fallopian tube. In two cases of extra-uterine conception, I have known such adhesion to be a consequence of disease in the lower part of the colon.

These instances of deviation from the natural action of the parts after conception prove to us, I think, that from the moment of impregnation there is a principle of life and activity in the system of vessels of the ovum, and that at a stated period this action becomes such, that the efflorescent vessels of the surface of the ovum attach themselves to whatever vascular surface they are in contact with. Further, it seems to show, that in the womb, and in the deciduous membrane which it prepares for the reception of the ovum, there is nothing very particularly necessary, and that any vascular surface will take upon it the same changes, and being excited probably to some peculiarity of action, will, in every thing essential, supply the growth and nourishment of the ovum and fœtus.

It shows us how far the action previous and consequent to impregnation is a universal and sympathetic excitement of the uterine system; that the decidua is formed in the cavity of the womb, although the ovum does not descend. This points out to us how careful nature is, that there shall be a reciprocal action in the ovum and womb, so as to insure the adhesion of the ovum, and the ready supply of a proper nidus for it, when it shall have descended into the cavity of the womb. It informs us, that the uterus is a spongy and vascular bed, having peculiar sympathies which actuate its vessels, and a form of vessels adapted to quick acceleration of action, so as to grow, and supply the secundines with nourishment.

It is not, however, in the mere adhesion and supply afforded to the fœtus, that the peculiar adaptation of the womb for the reception of the fœtus is shown, but in the provision for the delivery of the child at a regular and stated period. For it is a curious fact, that in the case of extra-uterine fœtus on the expiration of the nine months, the uterus takes upon it that action, and that excitement of its muscularity which is destined to expel the fœtus. We find, that at the usual time of utero-gestation there are pains excited, and flooding, with the discharge of the decidua from the womb, although it contains no fœtus.

Nay, further, it would appear from the result of several cases, that at the expiration of the natural term of utero-gestation, the fœtus indicates

that it is governed by prescribed laws, which render a change necessary, and show that its system is no longer fit to be supplied through the placentary vessels; and as in the situation of extra-uterine fœtus this change cannot take place, it dies, and becomes with its secundines as a load of foreign or dead matter in the belly. This event is generally followed by the death of the mother, though sometimes an abscess has opened and discharged the fœtus, or after much suffering, the bones have been discharged by stool, at long intervals.

OF THE WOMB AT THE FULL PERIOD OF GESTATION, AND OF DELIVERY.

To complete this view of the female parts of generation, it remains only to speak of the state of the parts at the full term of nine months, and to observe the process of a natural delivery.

The rapid increase of size of the pregnant womb, in the short space of nine months, is, perhaps, the most surprising phenomenon of the whole animal economy: it shows the power of a peculiar excitement in calling into action a partial and local system of vessels. This state of pregnancy is the furthest from a state of distention, insomuch, that it is observed the womb feels peculiarly soft on impregnation, and as if but imperfectly filled by the ovum. This soft state is a sign of vascular action. We may often observe in the discussion of a tumour, that before any change takes place, it swells and becomes soft, and this even where the tumour is about to be absorbed.

The fundus of the uterus is the part first enlarged, and afterwards the inferior parts; at length the cervix is obliterated, and the uterus, which was originally pyriform, becomes nearly oval; the distention, however, as we have remarked, is greatest on the back part of the womb. In the first months the uterus sinks lower in the pelvis, they say, from its weight; but the specific weight of the uterus is not increased, and on that account it should not sink deeper; it is, perhaps, rather from its enlargement, and the difficulty with which the fundus makes its way among the viscera in the brim of the pelvis. Having descended considerably, the os tincæ projects further into the vagina; but the fundus continuing to enlarge, at last emerges from the circle of the bones, and then from the conical form of the uterus, it sometimes rises suddenly out of the pelvis: now the vagina will be found elongated, and the os tincæ removed from the point of the finger.

Now the ligaments of the womb direct it forward, and it rises close upon the abdominal parietes, and before the bowels: in the first pregnancy, it rises almost directly up; in subsequent pregnancies, from the greater relaxation of the integuments and the abdominal muscles, it is allowed to fall more forward; about the fourth month of pregnancy, the womb may be felt in the abdomen, and rising out of the pelvis: in the fifth month, the fundus is about half way betwixt the pubes and navel; in the seventh, it is about half way betwixt the navel and scrobiculus cordis: in the eighth month, it is at its highest, and towards the end of the ninth month, it rather subsides. Finally, immediately before labour, it descends remarkably, and shifts into the middle of the pelvis, so as fairly to present the orifice of the womb.

The muscularity of the uterus is increasing from the first moment of

pregnancy. As the uterus increases in thickness and is distended, the muscular fibres become more distinct, and their power of contraction greater; but what is very particular, is the great muscular efforts made by the womb during labour by these fibres, which have not till that time felt the stimulus to action, or been allowed to contract.

When the period for the approach of labour is arrived, the nature of that viscid secretion which seals up the orifice of the womb is altered; it loses its viscidity, and all the parts are relaxed and prepared for the transmission of the head; even those rigidities, strictures, or callosities of whatever kind, which would seem to promise an absolute obstruction to the passage of the child, yield and relax previous to labour. The action of the womb is at first feeble, as might be expected, and accoucheurs have marked these stages of a natural labour:—

1st. The uterus has suffered no diminution of its size: the membranes are entire, and, of course, the contractions of the uterus are feeble, because, before it is allowed to make some contraction, its efforts are not strong. This is a provision for the first stage of labour being slow; by and by the orifice dilating, the membranes with the waters are felt protruding. The membranes and water are as a soft conical cushion, gently dilating the passage; and in this stage there should be no officious interference. While the membranes are entire, both the mother and child are in perfect safety.

2d. The orifice continuing to dilate, and the efforts of the womb increasing, the membranes burst, and the head of the child presses on the orifice; then the womb is allowed to contract: this contraction is a stimulus to greater efforts, and in a few pains, the head descends into the cavity of the pelvis. The orifice is completely retracted, and there is no longer a mark of division betwixt the womb and the vagina; they are as one canal. If, however, the membranes are burst too early, the labour is not accelerated, but retarded. The orifice is not dilated by the soft and elastic membranes; the head of the child presses broad on the orifice, which becomes rigid, and perhaps inflamed; its dilatation is slow, and the labour tedious. Though from the form of the bones, and particularly by the retiring of the sacrum, there is a provision and guard for the soft parts of the mother against compression by the head; yet nature intends this stage to be short, for it is the period of danger. There is now obstruction of urine and fæces, and the vessels of the parts suffer compression.

3d. Now the head of the child presenting at the orifice of the vagina, forms a third stage; it is the stage of most exquisite suffering: the head is pushed forward during every pain, and recedes again in the absence of pain. An interval of rest precedes this stage. At last the pains return, and the hard head of the child coming to press on the orifice, and the womb coming in close contact with the body of the child, the pains are redoubled in strength. The face of the woman, perhaps before pale and flat, becomes red and turgid, the eyes gleam, and are inflamed; the pulse becomes quick and hard; and from the exquisite expectation of relief, she looks wildly round on her attendants, losing all reason and recollection; she is frantic, with the most agonising pain to which the human frame is subject. Now the occiput of the child begins to project with its wrinkled scalp through the external parts; but nature intends

that this also should dilate slowly: the ligaments and os coccygis resist several throes, and direct the head forward under the pubes. At last, after several pains, it rises with a half turn, and is delivered.

4th. The fourth stage, is the delivery of the body and shoulders; and,

5th. The fifth stage is the delivery of the placenta. The placenta is expelled by a continuation of the same action of the womb, and is part of the natural process. First a flow of the liquor amnii and blood follows the child, and the woman lies for a time exhausted; the extreme pain and excitement having ceased. The womb generally recovers its powers in about twenty minutes, and then there is grinding pain in the belly, and the placenta is detached and expelled, or is pushed down into the vagina.

Thus we have sketched, in the most superficial manner, the progress of a natural labour, with a view merely to explain the general notion of the entire function of the womb, not with that minuteness which the accoucheur would look for in treating the subject. Let us for an instant attend to the state of the umbilical cord, and the final contraction of the womb.

I have already observed, that while the membranes are unbroken the child is safe, that is to say, there is no danger of the compression of the umbilical cord; but when the membranes have burst, and the waters are evacuated, the cord must suffer a degree of compression betwixt the uterus and the child, and there is danger that the cord may fall down before the head, until the head has descended into the brim: as the uterus contracts, and as it were follows the child, the circulation through the placenta must become somewhat difficult, and the usual function corresponding with that of the adult lungs impaired. This must be much more the case when the child is delivered, and the placenta remains in the contracted womb. No doubt nature intends by this, that the function of the placenta shall be gradually diminished, and not suddenly cut off, that the child may feel occasion for the play of the muscles of respiration, and that the function of the lungs may, by degrees, take place of the function of the placenta. When the child is first delivered, the cord pulsates strongly; when the child cries, it becomes feeble. At first the child has strong and irregular catches of the respiratory muscles, but by and by it breathes more regularly, and cries lustily. At first, the breathing only renders the pulsation of the cord feeble, but presently the pulsation becomes so weak that it is felt only near the umbilicus, and it ceases when the regular and uninterrupted breathing is established, and the crying ceases.

The delivery of the child and placenta is followed by a considerable efflux of blood. But after this there continues a discharge from the uterus which is called the lochia. It is like the exudation of blood from an extensive wound, in as much as by the contraction of the vessels from which it flows, it becomes serous in a few days, and ceases gradually like a hæmorrhage.

This open discharge from the womb after delivery, is no doubt a provision against the consequence which would naturally result from the sudden and perfect obstruction and the activity of the uterine vessels consequent on delivery. By this discharge the activity of the vessels is gradually relieved, and as it is a discharge taking place of the active

state of the womb, so the secretion of the milk in the breasts, and the giving of suck, causes the discharge to cease much sooner than it would do if the mother were not the nurse.

OF THE MUSCULARITY OF THE UTERUS

I HAVE dissected the gravid uterus in all conditions: in women who, in consequence of fever, died undelivered; in women who died from flooding, and in women who died in consequence of distortion of the bones: I have had two opportunities of examining the uterus ruptured by its spontaneous action; and one, in which the uterus had been ruptured by violence; and, finally, I have examined the state of the uterus after death in consequence of the Cæsarian section.*

In this way I have been led to attend to this subject as an anatomist, rather than as an accoucheur; an explanation which, I fear, will seem very necessary in apology for these observations.

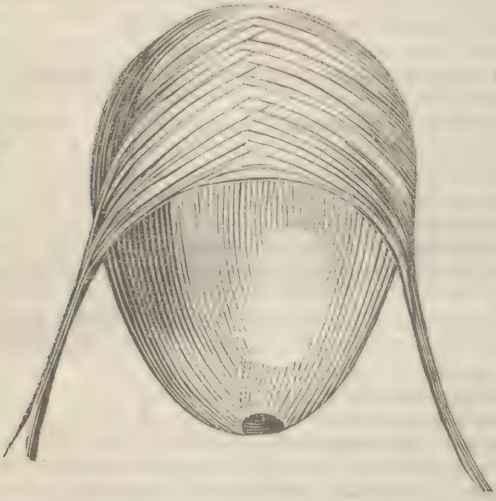
OF THE MUSCULAR STRUCTURE OF THE UTERUS.

The muscularity of the uterus is proved by direct ocular demonstration of the fibres in dissection; by the thickness of the fibres corresponding with their degree of contraction; by the visible action in the human uterus during life; by the resemblance of the laws of its contraction (as felt and as perceived in its consequences) to those which govern the contraction of the other hollow viscera; and, lastly, by the vermicular and intestinal motions of the uterus as seen in experiments upon brutes.

The prevailing notion that the muscular fibres of the uterus are very confused, and scarcely perceptible, has prevented authors from founding the rules of practice on the sure ground of anatomy. And if it be possible to place this matter in a clear light, it may banish, perhaps, a certain vagueness which is much to be regretted in so important a department of practice. The most curious, and obviously useful part of the muscular substance of the uterus, has been overlooked; I mean the outermost layer of fibres which covers the upper segment of the gravid uterus. The fibres arise from the round ligaments; and, regularly diverging, spread over the fundus, until they unite and form the outermost stratum of the muscular substance of the uterus. The round ligaments of the womb have been considered as useful in directing the ascent of the uterus during gestation; so as to throw it before the floating viscera of the abdomen: but, in truth, the uterus could not ascend differently; and on looking to the connection of this cord with the fibres of the ute-

* I wish that my present subject permitted me also to state what I have found on dissecting the parts after the use of the crotchet, and in particular where the forceps had been used, as I must presume, in a case improper for them. The injury which the seeming harmless instrument, the forceps, is capable of doing might then be proved, and a wholesome admonition given to the young surgeons.

rus, we may be led to consider it as performing rather the office of a tendon than that of a ligament. It is familiarly known, that the subsiding of the belly in pregnancy occasioned by part of the womb sinking within the brim of the pelvis, is the least equivocal sign of the approach of labour, and of the pelvis being of due dimensions; and in some measure this is also an assurance of a right presentation of the child. This layer of muscular substance operating on the round ligaments is well calculated to assist in expelling the fœtus; but also in a particular manner it is provided for bringing down the womb in the first stage of labour, and it is well calculated to give the uterus and the head of the child the right position with regard to the axis of the pelvis. From the connection of the lower extremities of the ligaments with the tendinous insertions of the abdominal muscles, we can conceive that this muscle and these ligaments may shift the position of the womb, and carry it off from the support of the ilium; but otherwise we should be at a loss to conceive how the uterus by its own action could adjust the position of the orifice for the delivery of the child.



On the outer surface and lateral part of the womb, the muscular fibres run with an appearance of irregularity among the larger blood-vessels; but they are well calculated to constringe the vessels whenever they shall be excited to contraction. The substance of the gravid uterus is powerfully and distinctly muscular, but the course of the fibres is here less easily described than might be imagined. This is owing to the intricate interweaving of the fibres with each other; an intertexture, however, which gradually increases the extent of their power, in diminishing the cavity of the uterus. After making sections of the substance of the womb in different directions, I have no hesitation in saying, that towards the fundus the circular fibres prevail; that towards the

orifice the longitudinal fibres are most apparent; and that, on the whole, the most general course of the fibres is from the fundus towards the orifice. This prevalence of longitudinal fibres is undoubtedly a provision for diminishing the length of the uterus; or for drawing the fundus towards the orifice. At the same time these longitudinal fibres must dilate the orifice, and draw the lower part of the womb over the head of the child.

In making sections of the uterus, while it retained its natural muscular contraction, I have been much struck in observing how entirely the blood-vessels were closed and invisible; and how open and distinct the mouths of the cut blood-vessels became, when the same portions of the substance of the uterus were distended and relaxed. This fact of the natural contraction of the substance of the uterus closing the smallest pore of the vessels, so that no vessels are to be seen, where we nevertheless know that they are large and numerous, demonstrates that a very principal effect of the muscular action of the womb is the constringing of the numerous vessels which supply the placenta, and which must be ruptured when the placenta is separated from the womb.

I have observed further, that although in producing contraction and thickening of a portion of the uterus, by boiling it, or by other artificial means, the fibres are made very evident, and the blood-vessels greatly constringed; yet they are not so effectually closed as in the natural contraction of the muscular fibres of the uterus. Thus we are led to contemplate the uterus as more peculiarly destined for the safe delivery of the secundines, than for the reception and growth of the ovum. Although its system of vessels be admirably adapted for an increase of action, and for rapid growth, yet it is not so peculiar in this respect as in its muscular structure; for we find that where the fœtus lodges in the ovarium it grows within the term of uterogestation, to the full size: but if the ovum separates from the ovarium, or from the Fallopian tube, in the example of extra-uterine fœtus, the woman dies of hæmorrhage, the blood flowing without being restrained by any system of muscular fibres capable of constraining the blood-vessels which are necessarily ruptured.*

The celebrated Ruysch discovered a circular muscle on the inner surface of the fundus of the uterus.† The use of this muscle, as he conceived it, is to draw the surface of the uterus by a gliding motion from the corresponding surface of the placenta, and thus to separate it and cast it off. By some the existence of this muscle of Ruysch is not admitted: and it has been supposed that he was deceived by the appearance of tortuous vessels.‡ I have nearly an absolute reliance on the ob-

* See a case by Dr. Clarke. Transactions of a Society for the Improvement of Medical and Chirurgical Knowledge. Mr. Taunton shewed me the parts where a rupture of the Fallopian tube in a case similar to this of Dr. Clarke had occasioned a fatal hæmorrhage into the cavity of the abdomen. A lady under my care for disease of the rectum died suddenly, with symptoms of internal hæmorrhage. She left a request that I should examine into the cause of her death. I found the membranes of an extra-uterine fœtus, at the third month, had burst and shed the blood into the abdominal cavity.

† Ruysch, Dec. 2. p. 34.

‡ By Boerhaave and Albinus. See in the Opuscula of Sandifort the words of Professor Germ. Azzoguidus, who has also the idea.

servations of Ruysch; and as I have made a section of the uterus, most exactly corresponding with the engraving in Ruysch's work, I must conclude that he was not deceived in what he saw.

In the papers of Dr. Hunter, published by Dr. Baillie, there is the first accurate observation of the concentric fibres which surround the openings of the Fallopian tubes; the description corresponding with the circular strata of fibres which Weitbrecht has seen encircling the mouths of these tubes.

Upon inverting the uterus, and brushing off the decidua, the muscular structure is very distinctly seen. The inner surface of the fundus consists of two sets of fibres, running in concentric circles round the orifices of the Fallopian tubes. These circles, at their circumference, unite and mingle, making an intricate tissue. Ruysch, I am inclined to believe, saw the circular fibres of one side only; and not adverting to the circumstance of the Fallopian tube opening in the centre of these fibres, which would have proved their lateral position, he described the muscle as seated in the centre of the fundus uteri. This structure of the inner surface of the fundus of the uterus is still adapted to the explanation of Ruysch, which was, that they produced contraction and corrugation of the surface of the uterus, which the placenta not partaking of, the cohesion of the surface was necessarily broken.

Further, I have observed a set of fibres on the inner surface of the uterus which are not described. They commence at the centre of the last described muscle, and having a course at first in some degree vortiginous, they descend in a broad irregular band towards the orifice of the uterus. These fibres, co-operating with the external muscle of the uterus, and with the general mass of fibres in the substance of it, must tend to draw down the fundus in the expulsion of the fœtus, and to draw the orifice and lower segment of the uterus over the child's head.

I have not succeeded in discovering circular fibres in the os tincæ, corresponding in place and office with the sphincter of other hollow viscera, and I am therefore inclined to believe that, in the relaxation and opening of the orifice of the uterus, the change does not result from a relaxation of muscular fibres surrounding the orifice. Indeed, it is not reasonable to conceive that the contents of the uterus are to be retained during the nine months of gestation by the action of a sphincter muscle. The loosening of the orifice, and that softening and relaxation which precedes labour, is quite unlike the yielding of a muscular ring.

NATURAL ACTION OF THE UTERUS.

While the uterus retains its whole contents, the action of its fibres is slow and feeble. Its first movement is to shift its position to direct the orifice aright, and to sink down until the lower segment of the womb rests upon the brim of the pelvis: this it does by the operation of the muscular fibres on the round ligaments, and during this shifting of its position are experienced the true dolores præsagientes. When the waters are discharged, the contractions are more powerful, the child's head presses on the orifice, and the fundus and body of the uterus are more powerfully excited. Now the upper and middle part of the uterus contract; but it is evident that the lower part of the uterus must, during

this contraction of the upper part, relax and stretch to permit the child's head to pass. While the child is contained in the uterus, the muscular fibres cannot greatly contract nor impede the blood in the circulating vessels of its substance. But when the child is expelled, then the contraction of the fibres is considerable, and then they take that arrangement which is inconsistent with a free circulation of the blood ; the vessels are constringed. By the time that the placenta is expelled by the contraction of the uterus, the vessels of the uterus are closed, and no active hæmorrhage follows.

ACTION OF THE UTERUS PRODUCING RUPTURE.

I have examined two cases of uterus ruptured by its spontaneous action, and one in which the violent attempts at delivering the child ruptured it. In the two first examples the circumstances of the labour, and the appearances on dissection, had a close resemblance. The labour was going on apparently well, when, after a violent pain, the woman vomited a dark matter : on examination, the child's head had receded ; on putting the hand on the belly of the woman, the form of the child could be distinctly felt. Such was the description I heard, when I came to open the body in the first case. I found the fœtus, cord, and placenta lying among the viscera, and the uterus contracted and drawn into the pelvis. The head of the child I found unusually enlarged by hydrocephalus. In the second case, the uterus only was brought to me. In both, the uteri were largely rent transversely, just within the orifice of the fore part ; and the margins of the rents were thin and ragged. In the first, the orifice of the uterus was dilated and obliterated : in the second, the lips of the orifice were still distinguishable, being imperfectly dilated and rigid.

In the third case of rupture of the uterus, which I dissected, the circumstances were very different : I went to see a woman, who, being remarkably distorted, I thought could not survive her labour. I found a gentleman engaged in assisting her ; he had proceeded, I believe with perfect propriety, to deliver the woman with the crotchet ; he had evacuated the cranium, and brought away the frontal and parietal bones : he had got the hook into the foramen magnum, and was endeavouring to bring down the base of the cranium laterally, to accommodate it to the flattened pelvis. In this, however, he could not succeed. On returning next day I found the patient dead : the body was afterwards conveyed to me. On opening the abdomen I found the uterus still containing the body of the child, and the placenta ; but an arm and shoulder projected through a rent on the left side and lowest part of the uterus : it was covered with slime and mucus, and the lips or margin of the rent were quite black and sloughy. It required my whole strength, standing on the table, to draw back the remains of the child's head, which were wedged in the distorted pelvis.

In the first instance I think the cause of rupture was, that the dilatation of the orifice of the womb was insufficient to admit the preternaturally large head to pass. In the second, the rupture was owing to the rigidity and insufficient dilatation of the orifice of the uterus, while the muscular action of its body was powerful. We know very well, that a

muscle during action acquires an additional power of cohesion, and consequently additional strength, but that when relaxed it is comparatively weak. This explains why the rupture takes place at the lower part of the uterus; for there we find, that during the most powerful contractions of the womb, there must be relaxation and dilatation to admit the child's head to pass, and that relaxation is weakness.* In the third case, the remote cause of the rupture was the obstruction to the labour, from the wedging of the child's head; the child being forced by the action of the womb into the pelvis, and by the pulling of the accoucheur in the operation of the crotchet, the uterus was bruised against the linea innominata; hence the appearance, peculiar to this case, of blackness and gangrenous sloughs on the edge of the rent in the uterus.† In this case also, the immediate cause of the rupture was the contraction of the uterus, in the attempt to force down and deliver the infant, the violence of which action falling upon the weakened part of the uterus, near the orifice, tore it: the head of the child being locked in the pelvis, was undoubtedly the cause why the whole child was not thrown into the cavity of the abdomen.

I have examined the uterus cut in the operation of Cæsarian section. On opening the belly, I saw the uterus lying contracted; but the wound of it was gaping, the lips everted, and it now appeared as if the uterus had been cut from the fundus to the neck. This singular appearance and deception I attributed to the contraction of the body of the uterus, while the edges of the incision remained paralysed and uncontracted.‡ The thickness of the womb was increased to four times the diameter it presented during the operation; but what most deserved attention was the appearance of the large vessels, now with open mouths, which during the operation were not apparent. From the mouths of those vessels the streaming blood had been coagulated, and now formed strings, reaching from the mouths of the vessels to the great cakes of coagulated blood which lay on each side of the abdominal cavity. Besides the coagulated blood which lay in the cavity of the abdomen, a large clot was in the cavity of the uterus.§

From this we see, that when the substance of the uterus is cut, either the muscular fibres do not fully contract, or in their contraction in consequence of being cut across, they do not constringe the blood-vessels.

The muscular structure of the womb becomes a subject of very great

* I shall not presume to deny, that the vagina and not the uterus has been sometimes ruptured: yet from the general resemblance in the circumstances of the cases of ruptured uterus, and the appearance of the torn parts, I think the rupture takes place in the uterus, near the orifice. If the orifice of the uterus be relaxed and open, the vagina will not remain rigid, the child's head will descend: if there be no resistance to the contraction of the uterus, the violence of the action cannot be such as to tear the parts. The child and placenta being found in the cavity of the belly, declares the rupture to take place before the full descent of the head into the pelvis, that is, before the final dilatation of the orifice of the uterus.

† The linea innominata was in this case very sharp; the skeleton is in my Collection.

‡ Precisely the same appearance presented in the case communicated by Dr. Hunter, Med. Obs. and Enq. v. 4. Mr. Thomson's incision was six inches in length of the gravid uterus: on dissection the uterus was found contracted to the size of a common melon, and the wound appeared nearly the whole length of its body.

§ This corresponds with the dissection in the case communicated by Dr. Hunter.

interest in connection with that of *flooding*; it has been proved by the sections of the uterus, made in different states of its contraction, that the order of the muscular fibres is such as to close the vessels; that where nature has provided for the attachment of the placenta, there the broken vessels are guarded by the provision of the surrounding muscular texture; but we know also, that during this contraction of the superior part of the womb, the lower part dilates and relaxes. Now if the contraction of the womb be essential to the safety of the mother, what will be the effect of the attachment of the placenta to a part of the womb which must relax during the labour? Every one knows the peculiar danger of the case of *placenta prævia*, that each labour pain, as it returns, increases the violence of the flooding, instead of checking it. In common cases, breaking the membranes and accelerating the labour, checks the flooding, and secures the safety of the patient; but when the placenta is attached to the orifice of the uterus, the reverse of this takes place.

From attention to the muscular structure of the uterus I have been led to conclude, that in common cases of flooding, during labour, the hæmorrhage is not accidental, in any other meaning of the term, than as it proceeds from the place of the uterus to which the placenta is accidentally attached: that the placenta cannot be partially separated if it be attached in a regular circle to the fundus of the uterus; and that flooding on the commencement and during the progress of labour, is owing to an irregularity in the shape and attachment of the placenta.

When the placenta is attached in a regular circle to the fundus uteri, it cannot be partially separated, and cannot be separated bodily, until the uterus is permitted to have a great degree of contraction by the delivery of the child; the circular muscles of the fundus being agents in a double capacity, that is, both expelling the child, and in constringing the uterine vessels; by the time that the child is expelled, the vessels of the fundus are greatly diminished in diameter. Further, the place and strength of these muscles being perfectly regular and uniform, their action must have the effect of equally drawing the surface of the uterus, which is in correspondence with the margin of the placenta, towards the centre of the fundus, and consequently of separating the surface of the uterus from the placenta; but no one part of it will be separated until the general restriction is nearly completed. This will not be the case when the margin of the placenta extends irregularly, or when the placenta is attached to the side of the uterus. After the delivery of the child in cases of flooding, it is not uncommon to find a portion of the placenta low down in the uterus, and separated, while the greater portion remains attached to the fundus. In examining the inner surface of the uterus by dissection, I have seen the part corresponding with the placenta irregular in its form, and extending towards the side and neck of the uterus. In such circumstances of the attachment of the placenta, the retraction of the lower part of the womb being to a greater extent than the fundus, will account for the too early separation of that margin of the placenta which stretches towards the orifice, and also for the hæmorrhage, which is a consequence of this partial separation; but in progress of the labour, and after the discharge of the waters, the more powerful efforts of the uterus draw the muscular fibres more closely around the blood-vessels, and then the flooding ceases.

The flooding which attends the torpor of the uterus in any circumstances, when the connection with the placenta is broken, will be very easily accounted for on recurring to the details of the anatomy given already.

OF THE MAMMÆ.

In man and in children of both sexes, there is no mark of the breast, but the little cutaneous papilla, or nipple. These tubercles are, however, surrounded by a zone or disk, of a brownish red colour, the areola.

At puberty, as we have said, the breast of the female becomes protuberant, and those parts which were in miniature, and without action, quickly grow into a firm glandular mass. The shape, rotundity, and firmness of the gland depends much upon the adipose membrane surrounding and intersecting the glandular body.

The glandular part itself is divided into little masses, which again consist of small granules. These several subdivisions of the glands are closely surrounded by membranes.

The lactiferous ducts are gathered together from these lesser granules, and unite into twelve or fifteen in number of a very considerable size, as they converge towards the root of the nipple. When milk is secreted, the glands are large, a remarkable distention of the ducts also takes place, for they are then become tortuous and varicose, and serve as reservoirs of the milk. Where they pass through the nipple, however, they are again contracted, and open by small pores upon its surface. The nipple is of a spongy and elastic nature, and suffers a distention or erection. When the nipple is contracted, the lactiferous ducts must be compressed, and perhaps coiled together, so that the milk cannot flow, or flows with difficulty; but by the sucking of the child, the nipple is distended, and the ducts elongated, so that the milk flows. There open upon the areola several superficial or cutaneous glands, which pour out a discharge to defend it and the nipple from excoriation.

Of the arteries, veins, or lymphatics of the mammæ, we need not treat here.

We have many occasions to observe the consent and sympathy which exist betwixt the womb and the breasts. On the first period of the menses, the breasts are much distended. In many women, at each return of the discharge, a degree of swelling and shooting pain is felt in them, and the enlargement and shooting pain in the breast, with the darker colour of the areola, is marked as the most prominent sign of pregnancy; with the ceasing of menstruation, which is the cessation of the usual excitement and action of the womb, the breasts contract and are absorbed. Any unusual stimulus or irritation in the womb, as polypus, or cancers, or even prolapsus and excoriation, will affect the breasts, causing them to enlarge and become painful.

When the function of the parts ceases, they seem to feel the want of the usual excitement to correct action, and are apt to fall into disease; so it is at least with the womb and mammæ, for at that period of life, when the system is no longer able to support and give nourishment to a child, and these parts subside from their usual action, they often become scirrhous or cancerous, and terminate existence by a tedious, painful, and loathsome disease.

EXPLANATION

OF

THE PLATES.

Explanation of Plate I.

Fig. 1.

The eye, with the cornea cut away, and the sclerotic coat dissected back. *

a. The optic nerve.

b. The sclerotic coat dissected back, so as to show the vessels and nerves of the choroid coat.

c c. The ciliary nerves seen piercing the sclerotic coat, and passing forward to be distributed to the iris.

d. A small nerve passing from the same source to the same destination, but appearing to give off no branches.

e e. Two of the venæ vorticosæ.

f. A point of the sclerotic coat through which the trunk of one of the veins had passed.

g. A lesser venous trunk.

h. The orbiculus ciliaris of Zinn; the ciliary ligaments of others.

i. The iris,

k. The straight fibres of the iris.

l. A circle of fibres or vessels which divide the iris into the larger circle k, and the lesser circle m.

m. This points to the lesser circle of the iris.

n. The fibres of the lesser circle.

o. The pupil.

Fig. 2.

A dissection of the coats of the eye, as they appeared when hung in spirits.

A. The optic nerve.

B. The sclerotic coat folded back.

C. The choroid coat hanging by its attachment to the sclerotic coat.

D. The vessels of the retina seen as they appeared suspended in the fluid; the medullary part of this coat being washed away.

Explanation of Plate II.

In this plate, the anatomy of the bones of the human ear is explained.

Fig. 1.

We have here the bones which form the chain betwixt the membrane of the tympanum and the membrane of the foramen ovale.

A. The malleus.

B. The incus.

C. The stapes.

D. The os orbiculare, which forms the articulation betwixt the incus and stapes.

Fig. 2.

In this figure we have a view of the inside of the temporal bone, the petrous portion being broken away: we see the cavity of the tympanum, the membrane of the tympanum, and the chain of bones.

A. The groove for the lodgment of the lateral sinus.

B. The hole in the sphenoid bone for the passage of the artery of the dura mater.

C. The petrous portion of the temporal bone.

D. The irregular cavity of the tympanum laid open by the breaking off of the petrous part of the temporal bone.

E. The membrane of the tympanum closing the bottom of the meatus auditorius externus.

F. The malleus, the long handle of which is seen to be attached to the membrane of the tympanum E.

G. The incus, united to the great head of the malleus F.

H. The stapes, which is seen to be articulated with the long extremity of the incus through the intervention of the os orbiculare.

Fig. 3.

Shows the division of the temporal bone into the squamous and petrous portions.

* See Zinn, Tab. iv.

Fig. 4.

A. The SQUAMOUS PART of the temporal bone.

B. The CIRCULAR RING, which forms the meatus auditorius externus in the child.

C. The ZYGOMATIC PROCESS.

D. Cells which afterwards enlarge into those of the mastoid process.

Fig. 5.

The petrous portion of the bone, with a view of the tympanum.

A. The CAVITY of the TYMPANUM.

B. MASTOID CELLS.

D. The FORAMEN OVALE, into which the stapes (see fig. 1. C. and fig. 2. H.) is lodged.

E. The more irregular opening of the FORAMEN ROTUNDUM.

Fig. 6.

Represents the labyrinth of the human ear, with the solid bone which surrounds it cut away.

A. The FORAMEN OVALE.

B. The three SEMICIRCULAR CANALS.

D. The COCHLEA.

E. The tube which conducts the portio dura of the seventh pair through the temporal bone.

Fig. 7.

Explains the manner in which the lamina spiralis divides the cochlea into two scalæ, and the opening of the one scala into the common cavity of the vestibule, and the termination of the other in the foramen rotundum.

A. The bone broken, so as to show the cavity of the tympanum.

B. The FORAMEN OVALE.

C. Cellular structure of the bone.

D. The FORAMEN ROTUNDUM.

E. One of the SCALÆ of the cochlea, which is seen to terminate in the foramen rotundum.

F. The other scala, which is seen to communicate with the vestibule.

Explanation of Plate III.

These two figures are taken from the beautiful plates of the Professor Scarpa, and illustrate the soft parts contained within the osseous labyrinth, and the distribution of the nerves.

Fig. 1.

There is seen the membranous semicircular canals, their common belly, and the distribution of the acoustic or auditory nerve.

a. The AMPULLA of the superior membranous semicircular canal.

b. The SUPERIOR MEMBRANOUS SEMICIRCULAR CANAL.

c. The AMPULLA of the external membranous canal.

d. The other extremity of the external canal.

e. The AMPULLA of the posterior membranous semicircular canal.

f. The POSTERIOR SEMICIRCULAR CANAL.

g. The common canal of the superior and posterior canal.

h h. The sac common to the membranous semicircular canals, viz. the ALVEUS COMMUNIS.

i. The body or trunk of the ACOUSTIC NERVE.

k. The larger branch of the nerve.

l. A filament of the nerve to the sacculus vestibuli.

m. The lesser branch of the acoustic nerve.

n. A filament to the cochlea.

o o. Filaments of the larger branch of the acoustic nerve to the ampullæ of the superior and exterior semicircular canals.

p. The expansion of the nerve on the common alveus.

qq. NERVUS COMMUNICANS FASCIEI OR PORTIO DURA.

r. The beginning of the spiral lamina of the cochlea.

s. The osseous canal of the nerve, which forms part of the foramen auditorius internus.

t. The COCHLEA.

Fig. 2.

The distribution of the nerve in the cochlea, seen by a section of the internal auditory canal and cochlea.

a. The SUPERIOR OSSEOUS SEMICIRCULAR CANAL.

b. The posterior osseous semicircular canal.

c. The external osseous semicircular canal.

d. The bottom of the great FORAMEN AUDITORIUM INTERNUM.

e. The trunk of the great acoustic nerve.

f. The ANTERIOR FASCICULUS of the acoustic nerve.

g. A plexiform twisting in the anterior fasciculus of the nerve.

h. A gangliform swelling of the nerve.

i. The greater branch of the anterior fasciculus.

k. The lesser branch.

l. A filament of the anterior fasciculus to the hemispherical vesicle of the vestibule.

m. A branch to the beginning of the lamina spiralis.

n. The POSTERIOR FASCICULUS of the acoustic nerve.

o. The filaments about to enter the tractus spiralis foraminulosus.
p. These nerves seen upon the modiolus.
qq. The filaments of the nerve passing forward betwixt the two planes of the lamina spiralis.
rr. Their termination on the soft part of the lamina spiralis.
s. The nerves expanded on the second gyrus of the modiolus.
tt. uu. Their further distribution on the lamina spiralis.
vv. The INFUNDIBULUM.
xy. The last turn and termination of the lamina spiralis in the infundibulum.

Explanation of Plate IV.

This plate represents the prostate gland, vesiculæ seminales, and lower part of the bladder, the parts being previously hardened in spirits, the vesiculæ were afterwards cut open.

A A. The body of the PROSTATE GLAND; it is that lower part of the gland which can be felt through the rectum.
B. The prostate gland is here cut into and dissected, in following the ducts of the vesiculæ.
C. The extremities of the ducts common to the vesiculæ seminales and vasa deferentia.
D D. The cells of the vesiculæ seminales, which are laid open by a section.
E. The LEFT VAS DEFERENS, which is also laid open to show the cellular structure which it assumes towards its termination.
F. The RIGHT VAS DEFERENS.
G G. The foramina, by which the vasa deferentia open into the common duct.
H. The lower and back part of the BLADDER.
I. The RIGHT URETER.

Explanation of Plate V.

This plate represents a section of the neck of the bladder.

A. The lower part of the urinary bladder near the neck.
B. The opening of the right ureter, which is marked 1. fig. iii.
C C. The substance of the prostate gland, which is cut through; its thickness, texture, and the manner in which it surrounds the beginning of the urethra, will be understood from this plate.
D. The urethra laid open.
F. The VERUMONTANUM, or CAPUT GALLINAGINIS.
G G. The points of feathers put into the openings of the vesiculæ seminales and vasa deferentia.

N. B. Round these ducts, on the surface of the verumontanum, and in that part of the urethra which is surrounded by the prostate gland, innumerable mucous ducts may be observed: into some of these small bristles are introduced.

Explanation of Plate VI.

A view of the penis, vesiculæ seminales, and prostate gland.

Pl. I.

Fig. 1.

Fig. 2

Fig 2

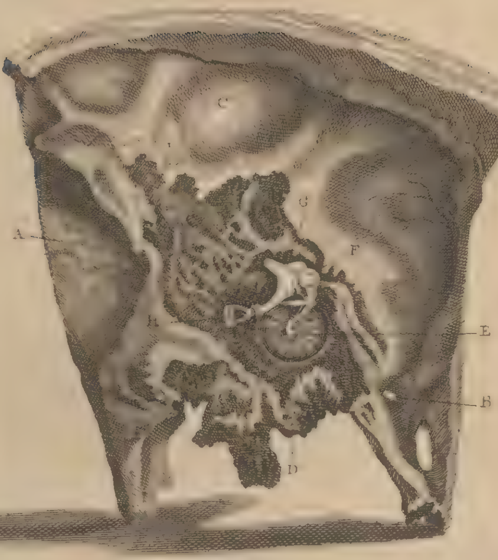


Fig 1

Fig 4

Fig 3

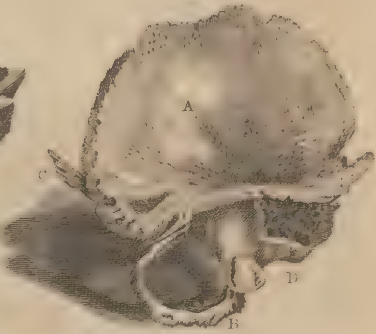


Fig 5

Fig 6

Bell del!

Leney sc!

Fig. 1.

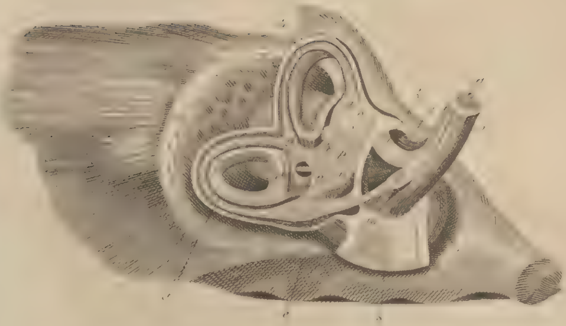
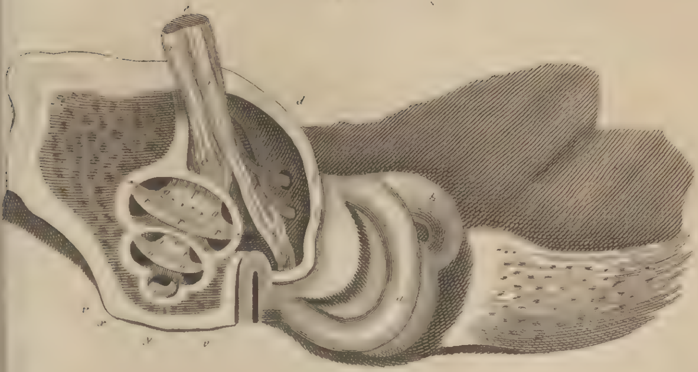


Fig. 2.



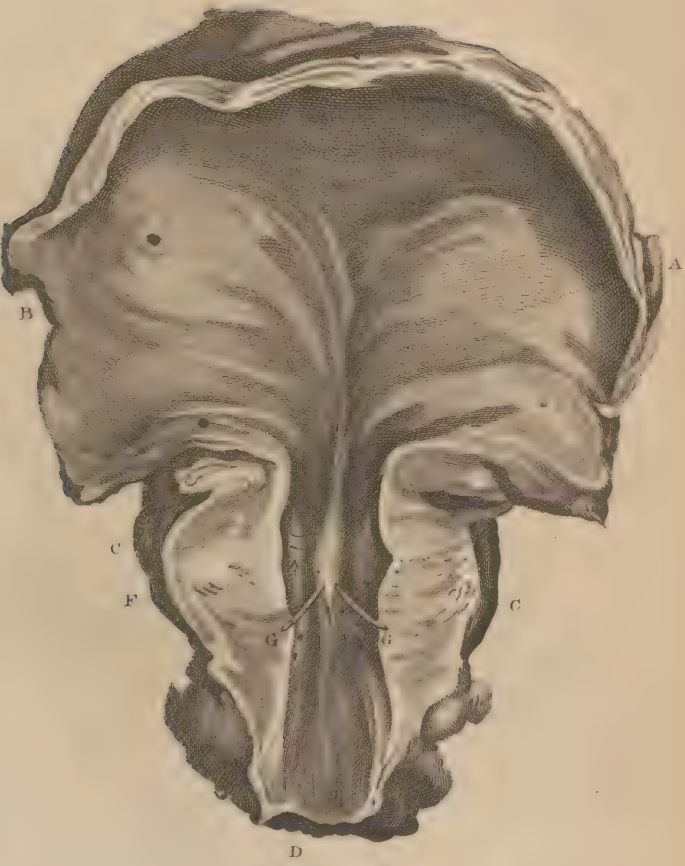
Bell del.t   Leney sc.t

Pl 4.

Bell del.t

Leney sc.t

Pl.5:



Bell del.t

Loney sc.t

Pl. 6.

Crus penis

Bulb of the Urethra

Membranous p.t of the Urethra

Prostate Gland.

E. Vesiculæ Semin

EF. Vasa deferentia

G. The Ureter

H. Bladder covered by the Peritoneum

W. del.t

Leney sc.t

APPENDIX.

A.

ANATOMY OF THE FŒTAL BRAIN.

[FROM TIEDEMANN.]

THE spinal marrow is divided into two cords by two grooves, the one anterior, the other posterior. Each of these two cords divide, in the medulla oblongata, into three smaller bundles, termed the pyramidal, olivary, and restiform fasciculi.

The two pyramidal fasciculi are situated on either side of the anterior longitudinal groove. Until the third month, they form a broad and plane surface, as in fishes, reptiles, and birds,* because the pyramidal eminences are not yet developed on their surface. On the fifth month they commence to form a projection on the outer side, in consequence of their being reinforced by medullary fibres of new formation. On the seventh month, each pyramid measures three lines in length, and one in breadth; on the eighth month, four lines and a half in length, and one in breadth; lastly, on the commencement of the ninth month, the length is four lines and a half, and the breadth one and a half. The crossing of the pyramidal fasciculi, which Mistichelli† and Pourfour du Petit‡ have described; which Santorini,§ Winslow,‖ Lieutand,¶ Soemmering,** and Gall†† have also observed, but which have escaped the researches of Haller, Vicq d'Azyr, Monro, and some others, and the existence of which these anatomists had doubted; this crossing, I say, is perceptible from the fourth and fifth week of fœtal life, at the point where the spinal marrow describes the curve forwards, corresponding to the inferior extremity of the pyramids. The two cords of the spinal marrow do not cross, but merely the middle or pyramidal fasciculi of each, which are composed of longitudinal fibres, and which give origin to the crura cerebri by expanding and becoming broader. Towards the third month, there is no difficulty in perceiving that these parts are really continuous, as the pons varolii does not yet exist; but at a later period their union, marked by the transverse fibres of the latter, becomes less apparent as this protuberance acquires more volume and breadth. If we remove with precaution the transverse fibres of the pons varolii, we observe those which they cover taking a longitudinal direction, and becoming continuous with those of the crura cerebri. The ancient anatomists, such as Varoli,‡‡ Vieussens,§§ and Morgagni,‖‖ were all aware that the medullary fibres of the pyramids traversed the pons varolii, and united with those of the crura cerebri; yet we cannot but acknowledge, that Gall has been the first to consider them as ascending from the spinal marrow towards the brain, while, before him, anatomists had supposed that they descended from the latter, and consequently looked on these as the origin of the spinal marrow. The latter part of this treatise will point out the degree of exactness and utility of the opinion of Gall.

* Thus Willis remarks (Anat. cerebri, p. 31). In volucribus corpora pyramidalia planè desunt.

† Trattato dell' apoplessia. Rome, 1709, in 4to.

‡ Lettre d'un médecin des Hospices du Roi. Namur, 1710, in 4to. p. 12.

§ Observationes Anatomicæ. Lyden, 1734, in 4to. p. 61: and in his Tab. Anatom. tab. 17.

‖ Traité de la Tête, n. 110.

¶ Anat. hist. et pract. t. i. p. 591.

** Bau des menschlichen Koerpers, t. v. part i. p. 68.

†† Anat. et physiol. du système nerveux, p. 192, pl. 5.

‡‡ De nervis opticis nonnulisque aliis præter communem opinionem in humano capite observatis. Padua, 1573, in 8vo. p. 18. fig. 1, 2.

§§ Neurographia universalis, tab. 16.

‖‖ Adversaria anatomica, VI. p. 16.

The fasciculi situated on the side of the preceding, but smaller, to which I have given the epithet of olivary,* as the eminences of this name are formed on their surface, pass upwards into the pons varolii, or are covered by this protuberance; afterwards they remain in apposition with the pyramidal fasciculi. The greater number of their fibres, which are longitudinal, collect in the common mass of the tubercula quadrigemina, and bending upwards and inwards, uniting to those of the opposite side, form that portion which becomes the roof of the aqueduct of Sylvius. The others are directed forwards into the optic chambers, where they unite with those of the pyramidal fasciculi. The corpora olivaria, which are wanting in fishes, reptiles, and birds, are only formed towards the end of the sixth month, or on the commencement of the seventh; a period when the unfibrous substance which constitutes them is secreted by the pia mater, and deposited on the medullary substance of the olivary fasciculi. The tardy appearance of the corpora olivaria depends on the grey substance not being formed until after the white. On the seventh month, each measures two lines in length, and one in breadth; on the eighth month, two lines and a half in length, and one and a fourth in breadth; and lastly, on the commencement of the ninth month, each is three lines and a half in length, and one and a fourth in breadth. Gall† considers these bodies as ganglia from whence the olivary fasciculi emanate; but, notwithstanding the description which this anatomist has given of the fasciculi themselves, in which he makes no mention of the medullary fibres, which are lost in the common mass of the tubercula quadrigemina, it is erroneous to suppose that they can come from the corpora olivaria, as they appear in the fœtus long before the formation of these eminences. I do not however pretend to deny, that the cortical substance, so richly provided with vessels, which deposit it on the surface, does not contribute to increase their energy and activity.

The cerebellic fasciculi, termed also the restiform bodies, the peduncles or posterior crura of the cerebellum, are the most external and posterior of the three cords into which the spinal marrow is divided. They rise from the lateral and posterior parts of this organ, form the swellings which border the fourth ventricle, and pass afterwards into the cerebellum.

Lastly, we observe on either side, on the margin of the posterior longitudinal groove, or at the entry of the canal of the spinal marrow, a very thin and narrow fasciculus formed of longitudinal fibres. In the fœtus of the fifth month, I recognised, for the first time, the presence of this fasciculus, manifest traces of which had also appeared in the spinal marrow of fœtuses the most advanced. It contracts the fissure of the canal of the spinal marrow. On a level with the calamus scriptorius, it inclines aside and passes into the restiform fasciculus. We can also distinguish it in the adult, along the posterior longitudinal groove.

A problem here presents itself. Is the spinal marrow a continuation, a simple appendix of the brain? or rather, is it the brain which we should consider as the continuation of the spinal marrow? Galen, Achillini, Beranger de Carpi, Vesalius, Coiter, Spigelius, Riolan, Columbo, Fallopius, Veslingius, Willis, Vieussens, Verheyen, Winslow, Haller, Zinn, Portal, and other anatomists, have supported the first opinion, to which are attached the greater number of suffrages. M. Gall justly opposed this hypothesis, and skilfully defended the contrary assertion. He required, however, many arguments to show that the opinion of the brain being but an appendage of the spinal marrow was new. Platon, Praxagoras, Philotomius, Plistonicus, and some other Greek philosophers had already professed that opinion. Galen had combated it with the same energy which many physiologists of the present day employ against Gall.‡ Thonet Bartholin,§ Malpighi,‖ and Fraccassati,¶ not content with adopting these, raised new arguments in its favour. However, though the opinion of Gall has not the merit of novelty, we must allow that this anatomist shares the honour of having attacked with advantage an erroneous doctrine, and of having

* These cords correspond to what Reil has termed the loop or knot.—Archiv. für de Physiologie, t. ix. p. 505, tab. 11, v, w, x, y.

† Anat. et physiol. du cerveau, p. 198, pl. 12.

‡ De usu partium, lib. 8, cap. 12. Quo loco subit mihi admirari Praxagoram, et Philotimum, non modò propter dogmatum absurditatem, verùm etiam propter eorum, quæ in anatomis appareat, ignorantiam. Superabundantiam enim quamdam seu spinalis medullæ propaginem, existimant esse cerebrum.

§ Anatome quintum renovata. Leyden, 1686, in 8vo. p. 428.

‖ De cerebro, in his Opera omnia. Leyden, 1687, in 4to. tom. ii. p. 116.

¶ De cerebro, in Malpighi opera, tom. ii. p. 134.

re-established that the ancients, of which he seems to be one of the most zealous defenders.

The researches which I have made on the brain of the fœtus, demonstrate that this viscus is produced by the superior part of the spinal marrow, that is to say, by the medulla oblongata, which increases and developes to give origin to it. I shall here collect the facts scattered in the first part of this work, in support of my opinion.

1°, We have seen that, in the beginning, the brain is very small in proportion to the spinal marrow, and even bears the type of this latter. In effect, it results from the prolongation upwards and forwards of its two principal cords: it is completely open superiorly, and the canal of the spinal marrow extends to the fourth and third ventricle; the cerebellum, and the common mass of the tubercula quadrigemina, consist but of two plates proceeding from the spinal marrow, naturally inclining, but not yet united.

2°, The cerebellum evidently proceeds from the spinal marrow, its two peduncles arising from the surface of the latter; they unite afterwards over the fourth ventricle, and then only do the stems, branches, and leaflets appear.

3°, We have seen the rudiments of the common mass of the tubercula quadrigemina, primarily membranes, formed by the olivary fasciculi of the spinal marrow; these membranes mutually unite, are gradually enlarged by new additions of substance, and thus insensibly acquire the disposition observed in the adult.

4°, I have shown that the pyramidal fasciculi of the spinal marrow, proceeding towards the antero-superior part, produced the enlargements termed the optic chambers and corpora striata; each then terminating in a thin plate, reflected from before backwards and from without inwards, formed the commencement of the cerebral hemispheres. These membranous hemispheres were still so short on the second month, as scarcely to cover the corpora striata. According as they developed, they extended farther backwards, so as to cover, on the third month, the optic chambers, on the fourth and fifth, the tubercula quadrigemina, and on the sixth and seventh, the cerebellum. Their inflexion on themselves gave origin to the lateral ventricles.

5°, I have demonstrated that the medullary fibres of the pyramidal fasciculi are directly continuous with those of the peduncles of the brain; that they pass from hence into the optic chambers, as also into the corpora striata, and that they terminate in expanding in the hemispheres.

6°, And lastly, we have seen that the new layers of cerebral substance are gradually deposited on the surface of the membranous hemispheres; that the walls of these latter gradually augment in thickness, and that only during the latter months do we perceive the convolutions.

All these particulars united, prove evidently that the cerebellum and brain are produced by the spinal marrow, and, to use the expression of Reil, are an efflorescence of this part. To these we may add the data furnished by the anatomy of the spinal marrow in the different classes of the animal kingdom; for the organization of the brain becomes more and more complicated as we ascend the scale from fishes up to man. In order to support the contrary opinion, that is to say, that the spinal marrow was a continuation, an appendage of the brain, the parts which we observe the first formed in the fœtus should necessarily give origin to this organ; we should consequently meet the brain and cerebellum before it; this is not the case. Besides, in reviewing the scale of the animal kingdom, where we see so evident a gradation in the formation and expansion of the organs, we should meet with a perfect brain before meeting a spinal marrow. We observe precisely the contrary, that is to say, that the spinal marrow of inferior animals is very voluminous, while their brain, forming really but an appendage, is very small; and we find this organ acquiring a greater volume and developement, according as we ascend the scale from fishes to mammiferous animals, a progress absolutely similar to what it follows when formed in the head of the human fœtus.

I could furnish still many other proofs in support of the principles which I establish; but it seems unnecessary, as nothing could persuade him who has not been already convinced by the arguments mentioned.

OF THE CEREBELLUM.

At the end of the first month, and on the commencement of the second, a soft and fluid substance occupies the place of the cerebellum. Towards the end of the second month, after having plunged the embryo in alcohol, we perceive, on either side, a small thin plate or a very narrow fasciculus, rising from the spinal marrow, along the fourth ventricle, turning inwards, and resting against that of the opposite side, without uniting to it. On the third month. these fasciculi have evidently augmented in volume, and represent then the corpora restiformia, termed the peduncles of the cerebellum by Willis, and the crura by other anatomists. Uniting on the middle line, they form a small narrow mass, extended like a bridge over the fourth ventricle. At this period the cerebellum is three or four lines in breadth : smooth and convex on the outer side, concave within, no appearance on its surface, of grooves, nor yet of lobes or leaflets. Its anterior surface is continuous with the membrane of the tubercula quadrigemina, and its posterior border inclined inwards.

On the fourth month, the cerebellum was five lines and a half in breadth, and one line and a half in length, in its middle part. It enclosed in a semicircle the common mass of the tubercula quadrigemina. On the inferior surface of the restiform fasciculi, appeared a small swelling, the rudiment of the ciliary body (corpus dentatum) or what has been termed by Reil the great medullary nucleus. In front of the peduncles of the cerebellum descends those fibres which wind round the olivary and pyramidal fasciculi of the spinal marrow, those of the right side uniting with those of the left, and forming thus the pons varolii, which was yet but one line in its longitudinal diameter.

On the fifth month, the cerebellum seemed to have increased in its transverse direction, and was a little flattened, its breadth being seven lines. At this period only, four transverse grooves are observed, deeper on the middle line than elsewhere, and gradually disappearing on the lateral parts. These grooves divided the organ into five lobes, which represented, in a perpendicular section, exactly five stems ; the branches or leaflets had not yet existed. The excavation of the internal surface of this organ formed the roof of the fourth ventricle ; the commissure which formed the pons varolii was two lines in length. The fibres distributed to the common mass of the tubercula quadrigemina, and the valve of Vieussens, had already existed. On the sixth month, the breadth of the cerebellum was eight lines ; its lateral parts had acquired a greater developement, and an elevation a little above the middle portion, which represented the processus vermiformis. The posterior notch of Reil was perceptible. The surface of the organ presented both deep and superficial grooves, which divided the lobes into lobules. In a longitudinal section, the stems, as also the branches, were apparent, and the ciliary bodies had acquired some volume. The pons varolii was two lines and a half in length.

On the seventh month, the breadth of the cerebellum was nine lines and a half ; the lobes were separated by very deep transverse grooves ; others more superficial were placed between the branches. The vermiform process was more sunk, in relation to the hemispheres ; and the nodule, the pyramid, the short cross bands, and the spigot, were discernible. The posterior edge, which enters a little inwards, formed the small valve, or small posterior medullary velum,* as also the peculiar appendages, termed by Reil the flocks. In a longitudinal section of the cerebellum appeared the stems, branches, and ramifications ; but the last divisions of leaflets were not yet visible. The fasciculi of the spinal marrow, which plunged into the hemispheres, formed large swellings, the ciliary bodies, from which some fibres rose into the stems, branches, and ramifications, and radiated towards the periphery. Some fibres, proceeding forwards, formed the prolongations of the cerebellum towards the tubercula quadrigemina ; while others descending, produced the pons varolii, now three lines in length, and four and three quarters in breadth.

On the eighth month, the cerebellum was eleven lines in breadth ; the hemispheres having acquired their developement, the vermiform process appeared more sunk. The longitudinal diameter was four lines and a half in the middle part, and six and a half on the sides. The soft substance which is deposited from without inwards on the ramifications, and which forms the leaflets, remained adherent to the folds of the pia mater, when this membrane was elevated.

* See Mayo's Anatomical and Physiological Commentaries, part i. p. 25.

On the ninth month, the breadth of the cerebellum was one inch four lines; its longitudinal diameter six lines and a half at the vermiform process, and nine on the hemispheres. All the parts were developed, and the leaflets had already appeared.

After this view, it is incontestable that the cerebellum proceeds from the two restiform fasciculi, emanating from the spinal marrow; an opinion which Fraccassati* had already supported. In effect, these parts are the first formed, and give origin to all those which are observed on the periphery of the organ. The ulterior developement and formation of the cerebellum are owing to new cerebral substance secreted by the vessels which the pia matter sends into its interior, and which surrounds it on all sides. The successive depositions of this substance are formed, the one on the surface, by the formation of the lobes, stems, branches, ramifications, and leaflets; the others, from below upwards, and from within outwards, by the formation of the ciliary bodies.† These bodies, termed by Gall the ganglia of the cerebellum, are visible from the fourth month, as I have already mentioned, and are produced by the numerous vessels sent from the choroid plexus of the fourth ventricle to the cerebellum. On their surface, as also on that of the corpora restiformia, the new substance is deposited, secreted by the internal surface of the pia mater. This membrane, augmenting gradually in extent, forms folds, which dip into the soft and diffluent cerebral matter of the new deposition: hence arise the transverse grooves and lobes observed on the fifth month, as also the divisions of the cerebellum into stems resting on the medullary nuclei. These depositions continuing, and the pia mater extending, the latter produces again new folds; the transverse grooves become more numerous, and the stems divide into branches, towards the sixth month. On the seventh and eighth, the cerebral matter is secreted in greater quantity, the pia mater still continues to form both deep and superficial folds, and not only the stems and branches appear, but also ramifications and leaflets.‡ Lastly, on the ninth month, an exterior layer of vascular cerebral substance is deposited on the surface of the medullary leaflets. Consequently the cortical substance is applied from without inwards on the surface of the cerebellum, and is the last production of the pia mater, as Reil has also conjectured.§

The separation of the cerebellum into two lateral parts, or hemispheres, and into a middle portion, the processus vermiformis, the commissure of the two preceding, only becomes apparent on the fifth month, after the formation of the medullary nuclei. In effect, according as the restiform fasciculi, which arise from the spinal marrow, augment laterally, by the production of these two nuclei, and enlarge by the increase of their proper mass, their volume and extent become more considerable, in proportion to that of the vermiform process; in this manner they give origin to the hemispheres of the cerebellum, and thus the posterior notch is also formed. The augmentation of the lateral parts gradually follows that of the ciliary bodies, a necessary result of the great number of blood-vessels which penetrate both these bodies and the hemispheres. Consequently, according as the hemispheres enlarge, the vermiform process not increasing in the same proportion, appears diminished in volume, seeming not only condensed, and more sunk, but still adding an apparent increase to the depth and breadth of the posterior notch, as the cerebellum approaches nearer the term of complete developement. To render this more evident, I shall state the comparative extent of the longitudinal diameter of the hemispheres, and of the processus vermiformis, during the different periods of fœtal life.

* Epistola de Cerebro, in Malpighi Op. t. ii. p. 125.

† Termed the festooned or denticulated bodies by Vicq d'Azyr, who has represented them, pl. xxxi. figs. 3, 4.

‡ Reil has already conjectured so (Archiv. für die Physiologie, t. viii. p. 278). He thus observes: "We might imagine, that the formation of fissures, or grooves, is effected from without inwards: the most superficial forming leaflets, while the deepest give origin to lobules and lobes."

§ Archiv. fur die Physiologie, t. viii. p. 393. The cortical substance is only applied on the surface of the medullary; it is separated, and consequently has no direct communication with it. P. 394. The cortical substance appears to be a precipitate furnished by the internal surface of the pia mater, and which gradually acquires a greater degree of density. Perhaps the brain is a series of similar precipitates, furnished successively by this membrane. At least it is certain, that, in the fœtus, this latter membrane is of extraordinary thickness, and we cannot perceive any distinction between the cortical and medullary substance.

Age of the Fœtus.	LONGITUDINAL DIAMETER.	
	Of the Vermiform Process.	Of the Hemispheres.
Fourth Month, ...	1½ Line.	1½ Line.
Fifth Month, ...	2⅓	2½
Sixth Month, ...	2	3
Seventh Month, ...	4	4⅔
Eighth Month, ...	4½	6⅓
Ninth Month, ...	6½	9

I could not very distinctly perceive, until the seventh month, the parts in the vermiform process, termed by Reil the nodule, pyramid, spigot, and short crossbands.

At the same time that the medullary nuclei were formed, so were the cords which joined the cerebellum to the tubercula quadrigemina, and those destined to form the pons varolii. This latter, composed of transverse fibres,* gave origin to the middle lateral cords, which surround the olivary and pyramidal fasciculi of the spinal marrow, beneath which they unite on the mesial line. These middle cords proceeded from the rhomboidal bodies, and from the white substance of the cerebellum, appearing as soon as the formation of the medullary nuclei, that is to say, on the fourth month. Gall† believes that they are formed by particular fibres, which he has termed, *Les fibres rentrantes*, which, according to him, arise from the grey substance extended over the leaflets, and proceeding from the cerebellum, unite and form the great commissure, or pons varolii. These fibres are imaginary, for the pons varolii, and the medullary fibres which constitute it, exist in the fœtus on the fourth month, that is to say, at a period when we find neither stems, branches, nor even leaflets, covered with cortical substance ; he has given them an origin from parts which only exist at a subsequent period. The pons varolii, thin and narrow at first, augments in breadth and thickness, according as the ciliary bodies and hemispheres of the cerebellum increase. Of this we may be convinced by the following table, which shews the extent of its diameter each month.

Age of the Fœtus.	Length of the Cerebellum.	Breadth of the Cerebellum.
Fourth Month, ...	1 Line.	
Fifth Month, ...	2	
Sixth Month, ...	2⅓	
Seventh Month, ...	3	4¾ Lines.
Eighth Month, ...	4	5
Ninth Month, ...	5⅓	6⅓

* Willis has already remarked this, (Anat. Cerebri, p. 32.)

† Anatomie et Physiologie du Système Nerveux, p. 182. Des filamens nerveux rentrans ou divergens, ou de la réunion (commissure) du cervelet. "Nous avons vu jusqu'a présent que les filets nerveux du cervelet, avant d'entrer dans le ganglion, et après en être sortis, s'écartent davantage les uns des autres, et s'épanouissent graduellement en couches et en feuilles ; que, par conséquent, ils occupent une circonférence toujours plus grande. Mais il y a encore un autre ordre de fibres nerveuses, qui n'ont pas de connexion immédiate avec le faisceau primitif, ni avec le ganglion ou l'appareil de renforcement. Ces fibres sortent de la substance grise de leur surface, se portent dans diverses directions, entre les filets divergens, vers le bord interne antérieur et forment ainsi une couche fibreuse, large et épaisse."

We shall shortly see that the pons varolii increases also in animals, according as the hemispheres of the cerebellum become more voluminous. I should remark here, that I have observed in the fœtus of six months, the groove which lodges the basilar artery, so well marked in adults, along the inferior surface of the pons varolii. As this artery exists prior to the pons varolii, and as it furnishes branches to the pia mater charged with the secretion of the substance which is to form it, it is evident that the groove now mentioned depends on the manner in which the cerebral pulp is deposited around the vessel.

The prolongations of the cerebellum towards the tubercula quadrigemina and valve of Vieussens, appear from the end of the third month, in the form of a small plate, which, detached from the anterior thin border of the cerebellum, gains the posterior margin of the membranes which are subsequently to form the common mass of the tubercula quadrigemina. According as the ciliary bodies are developed, these prolongations become more voluminous; and on the seventh, eighth, and ninth months, we can distinctly perceive the longitudinal fibres of the white substance which compose them.

The posterior valve, or valve of Tarin, termed the posterior medullary velum by Reil, is formed by the posterior border of the cerebellum, reflected downwards and inwards. This, as well as the flocks, is not observed until the seventh month.

B.

ABSORPTION FROM THE DIGESTIVE CANAL.

[FROM COPLAND.]

1. *Of Absorption from the Digestive Canal.* It appears, from the experiments of Tiedemann and Gmelin on absorption, that the lacteals take up the digested and dissolved portions of alimentary substances, and convey them as a chyle through the thoracic duct to the blood-vessels; but as odoriferous, colouring, and some saline substances, are not absorbed by them, and yet are found in the blood of the vena portæ, and in secreted fluids, it must necessarily follow, that there must be some other way, than the thoracic duct, by which they pass into the blood.

The following are the chief suppositions which have been offered in explanation of the facts :—" Either all the lacteals do not enter the thoracic duct, and part of them join the veins which form the vena portæ, and thus transmit their contents into the blood of the vena portæ; or substances pass directly from the stomach and intestinal canal into the veins; or finally, both of these suppositions may be true."

These physiologists found, that quicksilver injected into the absorbents of the intestinal canal easily reached the mesenteric veins and the vena portæ, and this communication was found to take place in the mesenteric glands. By means of this communication they explain the appearance of streaks of a substance like chyle, which is perceived in the blood of the vena portæ after taking food—a fact which has been frequently observed by other anatomists.

Though the passage of chyle into the vena portæ, may be explained by this connexion of the absorbents with the veins of the intestines, it would appear from the experiments, that the passage of odorous colouring and saline substances, does not take place in the same way. The presence of alcohol, gamboge, indigo, could never be detected in the lacteals, or thoracic duct, though it was abundantly manifest in the blood of the mesenteric veins, and in the vena portæ. They therefore conclude, that the passage of these substances must be effected through other channels, and that these channels must be the radicles of the veins of the intestines. It was found, on examining blood taken from a branch of the mesenteric vein of a dog, to which sulphuro-prussiate of potass had been given, that no streaks of chyle were present, but the saline matter was perceived. From this, and other experiments, they conclude that the veins of the intestines appear particularly to absorb heterogeneous substances, such as those already particularized, whilst the lacteals take up nutritious matter; and consequently, that substances taken into the digestive canal may pass into the mass of blood—1°, through the absorbents, and the thoracic duct; 2°, through absorbents,

which are united with veins in the mesenteric glands ; 3°, through the radicles or the commencement of the mesenteric veins which ultimately form the vena portæ.

And it seems established by the experiments, that the vena portæ receives chyle from the absorbents, and other substances which are taken up from the intestinal canal by the veins themselves, and as the blood of the vena portæ, into which these materials are conveyed, passes through the liver, this viscus must be regarded as an organ of assimilation as well as of secretion.

II. *Of Absorption in the Lungs.*—Professor Mayer, of Bonne, infers, from experiments instituted in order to ascertain to what extent absorption takes place from the lungs—

1°. That animals support a considerable quantity of liquid injected into the lungs, without experiencing mortal symptoms from them : but these injections should be performed by an opening made in the trachea.

2°. The symptoms of suffocation which arise from injections are not serious when we inject pure water : but they become so when thick fluids, for example, oil which obstructs the aerial passages, or some chemical solutions, which inflame the bronchial surfaces, are employed in this manner.

3°. The fluids and solutions injected into the lungs are absorbed more or less quickly, according to their nature, and their degree of concentration.

4°. This absorption is in general very great, but is less in young and newly born animals than in adults.

5°. Absorption takes place by the pulmonary veins, for it has occurred in the space of three minutes ; the fluids injected are found in the blood before they are perceived in the chyle ; they are found in the left auricle and ventricle of the heart, long before the least trace of them can be seen in the right auricle. Lastly, absorption is carried on even although the thoracic duct be tied.

6°. Absorption is likewise performed by the lymphatic vessels, but more slowly.

7°. The veins of the stomach and intestines also absorb, but in much smaller quantities.

8°. The existence of fluids absorbed by the veins can be demonstrated in the blood. It is easy to discover there the prussiate of potass, the muriate of iron, arsenic, &c. The prussiate of potass injected into the lungs can be traced, first in the arterial blood of the heart and arteries, then, if the injection be continued, in the venous blood.

9°. These substances can be discovered in abundance in the urine in the bladder, and in that in the kidnies. The prussiate of potass can be discovered in it seven minutes after the injection.

10°. The prussiate of potass is likewise deposited, and even in considerable quantity, in the serum of the pericardium, of the pleura, of the peritoneum, in the synovia, under the skin, and in the milk.

11°. When the prussiate of potass is injected, it can be discovered after some hours, not only in the fluids, but also in many of the solids : several of these parts then become green or blue with the muriate of iron, viz. the cellular tissue under the skin, and in the whole body, the fat, the serous and fibrous membranes, the aponeuroses of the muscles, tendons, the dura mater, periosteum, &c.

12°. The membranes of the arteries and veins ; even the valves of the heart can be thus entirely coloured blue by the same agent.

13°. The parenchyme of the liver and spleen cannot be coloured blue, but sometimes the cellular tissue around their great vessels. The lungs, the heart, and the kidnies, can be coloured blue.

15°. The substance of the bones and their marrow, the substance of the muscles and that of the brain, spinal marrow, and nerves, evince no change of colour with the muriate of iron. The nerves of the brain and spinal marrow seem to exert a repulsive and exclusive force, on the contact of fluids foreign to their nutrition. It may be concluded from this that the opinions of many physiologists, that poisons act mortally when they are applied to these parts of the nervous system, are not well founded, and are devoid of direct proofs.

16°. These experiments may also throw some light on secretion, the reproduction and nourishment of bodies ; they teach, moreover, the passage of liquids from the mother to the fœtus. When the prussiate of potass has been administered to the mother, it can be detected in the water of the amnion, in that of the chorion, and of

the umbilical vesicle, in the liquid of the stomach, in many solid parts of the fœtus, for example, in the kidnies, in the stomach, &c. as also in the placenta. When a fœtus, to the mother of which prussiate of potass has been given, is placed into a mixture of spirit of wine and muriate of iron, it becomes blue coloured. Thus we acquire a certain proof of the passage of fluids from the mother to the fœtus, a proof that has been vainly sought for until now :—the fluids taken into the blood of the mother are deposited in the tissue of the placenta, and are thence absorbed by the veins of the fœtus.

III. *Of the manner in which Absorption is performed : and of Exhalation.*—M. Magendie (*Journal de Physiol. Experiment. No. I.*) infers that the chyliferous vessels absorb chyle only, and that the veins possess the faculty of absorption. He has endeavoured to disprove the absorbent power of the lymphatic vessels, but in this he has not succeeded. He considers also that his experiments justify him in concluding, that, in all cases where artificial or real plethora exists, and the veins consequently are distended, no absorption takes place, or only in a slight degree, and after a greater length of time, than under ordinary circumstances ; whilst, when the original quantity of blood is diminished by venesection, absorption follows in one-fourth of the time in which it is found to occur when depletion has not been previously had recourse to. He considers it, therefore, to follow, that absorption is influenced by the congestion and calibre of the blood-vessels.

" The further pursuit of these researches led M. Magendie to the conclusion, that absorption is nothing more than the well-known phenomenon of *capillary attraction*, which takes place when tubes of a small calibre are immersed in fluids :—a phenomenon whose energy is in a direct ratio of the affinity of the fluid for the surface of the tube,—and in an inverse ratio with the diameter of the latter.

" It appears to me then," he adds, " beyond doubt, that all the blood-vessels, venous and arterial, whether dead or living, small or great, present in their parietes, a physical property calculated to account for the principal phenomena of absorption. To affirm that this property is alone able to produce all the phenomena of absorption would be to go beyond what is warranted by a correct logic ; but in the present state of facts on the subject, I know not any thing which weakens the inference which I have drawn, but many which may be adduced in its support."

" By this method of explaining absorption," he observes, " we solve a number of other phenomena in the living system otherwise inexplicable : for example, the principles on which dropsies are cured, the relief from congestion and inflammation produced by blood letting, the want of efficacy in medicines during those febrile states of the system in which the vascular system is greatly distended, the propriety of that practice which institutes blood-letting and purging prior to the administration of other active medicinals, the rationale of both partial and general dropsies, under circumstances of cardiac or pulmonary diseases ; the use of ligatures upon limbs after the bite of venomous animals, in order to prevent the consequences of such accidents," &c.

That absorption takes place exclusively through the medium of the veins cannot, in our opinion, be granted to any part of the body or to any organ, excepting to the brain. As respects this organ, we believe that sufficient proofs exist of this function being performed entirely by this set of vessels.

This very interesting subject has been further investigated by MM. Segalas and Fodéra. (*Journ. de Physiol. April* 1822. *and Jan.* 1823.) The latter physiologist entered upon a series of experiments, which, although they appear not to us fully to substantiate the opinion of M. Magendie that venous absorption takes place by capillary attraction, seem nevertheless to shew that this process, or one similar to it, actually exists to a certain extent in the living body ; and that though it may be subordinate to more energetic influences, it should not be altogether overlooked in our inquiries into the operations of the animal economy.

M. Fodéra's end, in his experiments, has been to demonstrate that exhalation, which he calls *transudation* : and absorption, which he names *imbibition*, are similar phenomena, owing to the capillary attraction of the parietes of the different vessels, owing to their porosity, operating, in the first case, from the interior of the vessels to the exterior, and in the second from the exterior to the interior.

M. Magendie conceived he had already proved that venous absorption takes place by imbibition, and came to the conclusions which we have now stated. One of his experiments consisted in completely isolating a portion of vein, and placing its surface

in contact with an active poison: its presence was soon discovered at the internal surface of the vessel. M. Fodéra then inversed the experiment. He injected a poisonnous substance, with every proper precaution, into the interior of a portion of artery comprised between two ligatures, and isolated from its cellular tissue, its lymphatics, and its *vasa vasorum*: poisoning took place. He obtained the same result by filling with poison a portion of an artery, vein, or of intestine, removing and placing them either at the surface of a wound made in another animal, or in the abdominal cavity. In these different experiments, the rapidity of the poisoning appeared to vary according to the age and kind of animal; the thickness and length of the portion of vessel or intestine, its greater or less distention: the more or less perfect solution of the injected matter, &c.

M. Fodéra has also seen gases absorbed in the same manner. He placed on the peritoneal cavity of a rabbit sulphuretted hydrogen, enclosed in a portion of intestine removed from another animal; and at the end of some time, symptoms of poisoning manifested themselves, and the sulphuretted hydrogen was no longer found in the intestine.

If, in a living animal, an artery or vein is exposed, an oozing is observed to take place through its parietes. This oozing augments, if a ligature be applied to the vessel: different dropsies may likewise be produced by the ligature of the great venous trunks.

M. Fodéra concludes from these facts, that exhalation is only a phenomenon of transudation through the parietes of the vessels, as many physicians had thought, before the exhalent vessels were imagined.

The following experiments prove that, at least, on the dead body, transudation of liquids may take place at the same time from the interior to the exterior, and *vice versâ*, through the vascular or intestinal parietes. M. Fodera filled a portion of a rabbit's intestine with a solution of prussiate of potass, and plunged into it a solution of hydrochlorate of lime: he introduced into another portion some hydrochloric acid, and surrounded it with sulphuric acid: finally, he placed a bladder, filled with tincture of turnsol, in a solution of gall nuts. Some time afterwards he found in the interior of these portions of the intestine and of the bladder, hydrochlorate of lime, sulphuric acid, and gallic acid, by the tests of nitrate of silver, hydrochlorate of barytes, and sulphate of iron; and in the liquids in which they had been immersed, prussiate of potass, hydrochloric acid, and tincture of turnsol, by the tests of sulphate of copper, the nitrate of silver, and by the reddish colour of the solution of galls being rendered bluish by the potass.

On injecting at the same time into the pulmonary vein of a sheep, a solution of hydrochlorate of barytes, and one of the hydrocyanate of potass into the trachea, M. Fodéra also found hydrocyanate of potass in the pulmonary artery, and hydrochlorate of barytes in the bronchiæ.

Similar phenomena may be produced in a living animal. M. Fodéra has found, for example, in the bladder or in the thorax, substances which had been injected into the peritoneum; and in the abdominal cavity, substances which had been introduced into the thorax or bladder. In these experiments he employed the solution of gall and sulphate of iron, or rather, the latter salt and prussiate of potass.

The black or blue colour, announcing that transudation has taken place, is frequently not observed until the end of more than an hour: it may be rendered almost instantaneous by putting in action the galvanic influence. For this purpose, this ingenious experimenter injects into the bladder, or into a portion of the intestine of a living rabbit, a solution of prussiate of potass, communicating with a copper wire; externally, he places a cloth wet with a solution of the sulphate, communicating with an iron wire: these wires are put in contact with those of the pile. If the galvanic stream be directed from the exterior to the interior, by making a communication between the iron wire and the *positive* pole, and between that of copper and the *negative*, the tissues of the organs imbibe the Prussian blue: if the stream be changed, the colour appears on the cloth.

M. Fodéra injected into the left cavity of the thorax of a rabbit a solution of hydrocyanate of potass, and into the peritoneum a solution of sulphate of iron; he afterwards kept the animal placed on its left side for three quarters of an hour. At the end of this period the animal was opened, when he found that the whole of the tendinous part of the diaphragm had imbibed the blue matter: the muscular part was much less tinged, and only in isolated points. The substernal lymphatic glands were likewise blue. The thoracic duct contained a bluish liquid; the

peritoneal membrane of the stomach and duodenum was coloured with spots of the same colour; they were observable, but in less number, on the rest of the digestive canal and on the arteries. The lymphatic glands of the mesentery, the suspensory ligament of the liver, the epiploon, were also tinged with blue. Some small subperitoneal veins presented a slight blue coloration of the liquid contained in their interior. Twelve hours afterwards, the blue tint of these different parts was much more intense.

The progress of the coloration may be traced, and the phenomenon in some measure be seen in its different *phases*, by injecting a ferruretted solution of prussiate of potass into a portion of the intestine of a living animal; tying both ends, and plunging it into a bath containing sulphate of iron. At first a slight coloration only, is observable in the parts, which gradually becomes deeper; afterwards the liquids of the lymphatics and of the blood-vessels become coloured in its turn. In the latter, the coloration begins by small ramifications, and afterwards extends to the branches, which are observed to be filled with intervals of blood and a blue liquid. In these experiments M. Fodera discovered the presence of the prussiate of iron in the lymphatic vessels, in the thoracic duct, and, finally, in the portion of the inferior vena cava contained in the chest.

M. Fodéra concludes, from these different experiments, 1st, that exhalation and absorption take place by transudation and imbibition, and depend on the *capillarity* of the tissues; 2dly, that this double phenomenon may take place in every part, and that the liquids imbibed may be conveyed equally well, either by the lymphatic vessels, or by the arterial or venous. But (the author very wisely adds) the phenomena of exhalation and absorption ought not to be considered as connected alone with imbibition and transudation; the modifications which they experience from the action of surrounding agents, from the nervous influence, the state of rest and motion, the energy of the circulation, the affinities of the substances with the tissues, the derangements produced by disease, and the elaboration which the fluids undergo whilst absorption and exhalation are taking place, ought likewise to be studied.

M. Fodera endeavours to explain the increase of exhalation in the phlegmasiæ by the dilatation which the parietes of the capillary vessels experience; the interstices of the fibres which form these parietes become at such times increased, and, consequently, permit a more ready issue to the fluids; the serosity and the white globules, which are smaller than the red, are first effused; at last the red globules themselves occasionally escape. It will be seen that this mode of conceiving the phenomena does not explain the infinite modifications which the liquids exhaled into the inflamed parts undergo.

M. Fodéra notices cases in which the lymphatics or thoracic duct have been said to contain different substances, which had been introduced either into the digestive canal, the serous cavities, or into the cellular tissue. If the effects of absorption are not manifested, in the experiments, where a portion of intestine, containing poison, has no longer any communication with the rest of the body, except by a lymphatic vessel, we must seek for a cause in the extreme slowness of the circulation of the lymph. M. Fodéra inserted some liquid prussiate of potass in the subcutaneous cellular tissue of the thigh and abdomen of two young rabbits. In the first animal, at the expiration of a few minutes, and in the second, at the end of half an hour, he found it in the lymph of the thoracic duct, in the urine, the mucus of the intestines, the synovia, the serum of the blood, the serosity of the pericardium, of the pleura, and of the peritoneum, as well as in all the solid parts, except in the crystalline lens, the cerebral substance, the interior of the nerves, and the osseous tissue. In another experiment the interior of the nerves presented traces of it.

Would not these experiments tend to prove that absorption in these cases had taken place at the same time, both by the lymphatics and blood-vessels?

While the German physiologists have ascribed absorption to the absorbents and veins only, MM. Magendie and Fodéra have extended this function to the arteries also. In this, however, we think that they have been misled by fallacies which had crept into their experiments, and especially by the unnatural position and deranged actions which the operations and agents required by the experiments induce in the animal and in the parts experimented on. From every consideration we are led to infer, that the inferences at which Tiedemann, Gmelin, and Mayer have arrived, approach the nearest to truth.

The experiments performed by Darwin, and more recently by Wollaston, Brande,

and Marcet, tend to prove that different substances introduced into the stomach are found mixed with the urine, without having passed by the lymphatic or blood-vessels.

M. Fodéra has repeated these experiments, and made them undergo an ingenious modification, which has discovered to him phenomena unobserved by former physiologists. He introduced into the bladder a plugged catheter, after having tied the penis in order to prevent the urine from flowing along the sides of the sound. He laid bare the œsophagus at the anterior part of the neck, and injected into the stomach a solution containing some grains of the ferruretted hydrocyanate of potass. This being done, he frequently removed the plug, and received on filtering paper the urine which escaped. On this paper he dropped a solution of sulphate of iron, and added to it a little hydrochloric acid, in order to destroy the colour. In one experiment the prussiate was detected in the urine ten minutes after its injection into the stomach, and in another five minutes afterwards. The animals were opened immediately. The salt was found in the serum of the blood taken from the thoracic portion of the vena cava inferior, in the right and left cavities of the heart, in the aorta, the thoracic duct, the mesenteric glands, the kidnies, the joints, and the mucous membrane of the bronchiæ.

This important experiment proves the extreme rapidity of absorption; it shows also that the prussiate of potass found in the urine, is conveyed thither by the ordinary circulating ways.

The following experiment demonstrates the rapidity of pulmonary absorption in particular. M. Fodéra opened the thorax of a rabbit, and removed the heart immediately after some prussiate of potass had been injected into the trachea. This operation was performed in twenty seconds; the interior of the left auricle, however, presented a bluish green colour, which was more deep at the *mitral* valve and less apparent in the aorta. The absorption, therefore, seems to take place at the very instant when the injection has penetrated into the subdivisions of the bronchiæ.

We are of opinion, that to limit the process of absorption in every part of the body, and under every combination of circumstances to which it is subject, to one particular process, or to one particular conformation or property which the vessels, whether blood-vessels or others, may possess, would, in the present state of our knowledge, be to draw an inference not justified by many important facts. On the contrary, it seems more probable that not only the vital properties, but those of a physical nature, are requisite to the production of the phenomena in question; and that the latter set of properties are under the control of the former.

Instead of attempting to show that those physical properties for which MM. Magendie and Fodéra have contended, are not to a certain degree efficient in the production of the process in question, we would only argue for their subordinate character, which may be proved by evidence still more uncontrovertible than that which M. Magendie has adduced in support of his purely physical properties; but, although the vital properties are chiefly predominant in the operation, yet those for which they contend may have still a place to a certain extent, which extent is modified by a superior influence.

Investigations into the process of absorption have also been entered upon in Philadelphia. Doctors Lawrence and Coates made thirty-four experiments, in which the prussiate of potass was introduced into the alimentary canal; from these it appears that articles taken into the stomach may be conveyed into the circulation by three channels; namely, the vena portæ, the œsophageal veins, and the thoracic duct, and if all these are closed, the absorbed matters are no longer conveyed to the circulation or to the urine. With regard to the quantity conveyed by each, they had no accurate means of judging. As the quantity of fluid, however, contained in the vena portarum, is so much greater than in the thoracic duct, it follows, that to produce a colour of equal intensity, a much larger amount of the colouring matter is requisite, and, as the serum of the blood of the vena portæ gave an equally deep colour, the greater proportion of the materials must have been absorbed through the veins contributing to this system of vessels.

In consequence of reading the experiments of professor Mayer of Gottingen, upon absorption in the lungs, Doctors Lawrence and Coates made a few with that reference.

The animals generally died in about a minute after the injection, from suffocation, by the ligatures which they placed on the tracheas of most of them. These experiments, we think, go to favour the idea that absorption from the mucous membrane of

the lungs, is performed principally by the pulmonary veins. They lay particular stress upon experiments 5th and 6th. In the first, the blood from the left side of the heart indicated the agent in much larger proportion than that from the right side, both being examined about the same time: viz. seven minutes. In the second, where the examination was made in a much shorter period, viz., three minutes and a half, and four minutes and a half, the article was distinctly found in the left side of the heart before it had arrived in any other part of the system.

The effect of infiltration was also remarkable in these experiments.

The results of five trials of the prussiate in the *cavity of the abdomen* are here arranged for inspection.

Animals.	Quantity.	Thoracic Duct.	Carotid and Jugular.	Urine.
Kitten.	½ oz. of solution.	12 & 13 m. distinct blue.	6 m. distinct blue.	19 m. no blue.
Idem.	Idem.	4 m. blue.	2 m. no blue.	10 or 15 m. no blue. 29 m. distinct blue.
Idem.	Idem, nearly.	3¾ m. blue.	2 m. no blue.	5 m. blue, not strongly.
Idem.	½ oz.	3 m. blue.	4 m. strongly blue.	More than 4 m. doubtful.
Cat.	Uncertain.	9½ m. blue.	6 m. no blue.	More than 9½ m. no blue.

The short time in which the prussiate reached the upper part of the thoracic duct in the above cases, induced them to make four other trials in order to ascertain the earliest period at which that took place. Half an ounce of solution was employed in each case.

In the first animal, a kitten, the salt first arrived at the spot of observation in four minutes, and the quantity gradually increased till seven or eight minutes. In the second kitten, it appeared in two minutes. The serum of this animal gave a blue tinge. In the third kitten, in three minutes and a half. Serum of blood also blue. In the cat, it first appeared in thirteen minutes.

In these cases, the thoracic duct was cut off near its insertion; and the test applied there. In consequence of this interruption, previously to the prussiate arriving at the upper extremity of the duct, the discovery of the salt in the serum of the blood clearly evinces that it was conveyed there by other channels.

It is mentioned by Magendie, that he has seen, on pressing the lacteal branches so as to discharge their contents in the direction of the trunks, that those branches would again fill themselves after the animal's death. They have also witnessed these appearances: but they do not know of any similar observations to the following made on the lymphatics, or of any evidence of the actual chemical presence of an article conveyed after death into either of these systems from without.

Four kittens were bled to what is commonly considered death. The blood ceased to flow from the divided carotid, and voluntary motion was extinct. Prussiate of potass in solution was then thrown into the abdomen. It appeared at the thoracic duct in five and a half, five, fourteen, and twelve minutes respectively. In the two last, the great vessels originating at the heart were secured by a common ligature. The blue colour was in every instance perfectly distinct.

In reasoning on the subject of absorption, the question has frequently arisen, whether the articles found in the living fluids exist there as chemical substance, or have their

chemical nature altered and animalized by the action of the vessels through which they have entered the system. It was, however, deemed a curious subject of inquiry, whether artificial chemical changes can take place in the fluids while they continue to circulate in living vessels, and the ordinary actions of life go on. With a view of ascertaining this point, they commenced by throwing prussiate of potass into the abdomen, and green sulphate of iron into the cellular tissue, in order to try whether the well known result of their admixture, the prussian blue, would be produced in the vessels. This, however, did not take place: and they resolved to repeat it, by throwing the sulphate, as the article of more difficult absorption, into the abdomen, where this process went on with more facility, and the prussiate into the cellular substance. On performing this, they were gratified by the striking result of a distinct and beautiful blue in the thoracic trunk, and its contents, and in nearly the whole substance and surface of the *lungs*. These viscera were preserved in spirits, and are now in their possession. The blood threw up a coagulum of a strong blue colour, and the lymph and chyle from the thoracic duct, threw down a blue deposit. Thus not only a foreign, but a pulverulent substance could present its unnatural stimulus and circulate through the vessels, and accumulate in the lungs, without preventing the actions of life from considerable exertion, and without occasioning coagulation of blood. The animal manifested some difficulty of respiration before she was killed, but walked about without the least difficulty, and uttered no cries, nor other signs of disturbance of its powers. In another case, the urine and lungs were noted as exhibiting a blue colour. The other parts similar to those above enumerated, are not described as being found coloured. In a third, the fluid in the thoracic duct was blue, but not the other fluids examined, nor the lungs. Two unsuccessful trials were also made. In another case the thoracic duct was tied, and the same process repeated. A divided bluish green was here found in the urine; but neither the serum of the arterial blood, nor the lymph of the ductus thoracicus, manifested the blue or green.

C.

CHEMICAL CONSTITUTION OF THE SOLIDS AND FLUIDS OF THE HUMAN BODY.

[FROM THE SAME.]

I. *Simple substances entering into the Constitution of the different Animal Principles or Constituents of the Human Body.*

The following simple substances are variously combined, in order to produce the *constituent parts* of the body:

1. Azote,
2. Carbon,
3. Hydrogen,
4. Oxygen,
5. Phosphorus,
6. Lime,
7. Sulphur,
8. Soda, (*Sodium*,)
9. Potass, (*Potassium*,)
10. Muriatic Acid,
11. Magnesia, (*Magnesium*,)
12. Silica,
13. Iron,
14. Manganese.

Of these, magnesia and silica may be considered as foreign bodies: they being seldom found, and in exceeding small quantities. The principal elementary ingredients are the first six: animal substances may be considered as chiefly composed of them The first four constitute almost entirely the soft parts; and the other two form the basis of the hard parts.

II. *Animal Constituents or Principles.*

I. Gelatin consists of Carbon, 47.88; Hydrogen, 27.20; Oxygen, 27.20; Azote, 17.00; or of 15, 14, 6, 2, atoms respectively. Contained in skin, bone, tendons, &c. *Test*, Tannin.

II. Albumen. — Corrosive sublimate detects $\frac{1}{2000}$ part the weight of the water contained in it. Comp. — Carbon, 52.883; oxygen, 23.872; hydrogen, 7.540; azote, 15.705 in 100 parts. Dr. Prout found it to consist of 15 atoms of carbon, 6 of oxygen, 14 hydrogen, 2 azote, according to the analysis quoted.

III. Fibrine varies in its species in the different classes of animals. Comp.—Carbon, 53.360; oxygen, 19.685; hydrogen, 7.021; azote, 19.934. Consists of carb. 18 atoms, oxyg. 5, hydrog. 14, azote 3.

IV. COLOURING MATTER OF THE BLOOD.—Berzelius found it possessed of nearly the same properties as fibrin. It is soluble in water at a low temperature; and in all the acids, except the muriatic, contains iron. (*Berzelius, vol.* 3, *Med. Chirurg. Trans.*)

V. UREA, or NEPHRIN, soluble in water and in alcohol. Precipitated in pearly crystals by nitric acid and oxalic acid. Dissolved by a solution of potass or soda.

Oxygen,	39.5	2 atoms	Hydrogen,	0.25	6.66
Azote,	32.5	1	Carbon,	0.75	20.00
Carbon,	14.7	1	Oxygen,	1.00	26.66
Hydrogen,	13.3	1	Azote,	1.75	46.66
	100			3.75	100

(*Dr. Prout.*)

Gelatin is insoluble in cold water, albumen is insoluble in hot, and fibrine is insoluble in both cold and hot.

The constituents of these three bodies, and of nephrin, according to the best analysis of them hitherto made, are as follow:

	Carbon.	Oxygen.	Hydrogen.	Azote.
Gelatin, atoms	15	6	14	2
Albumen,	17	6	13	2
Fibrine,	18	5	14	3
Nephrin,	1	1	2	1

The colouring matter of the blood approaches albumen in many of its properties; but it seems entirely destitute of azote.

VI. MUCUS.—Insoluble in water, transparent when evaporated to dryness, and, like gum, soluble in the acids. Not soluble in alcohol or ether—does not coagulate by heat—nor is precipitated by corrosive sublimate, or by galls. Is precipitated by the acetates of lead, and by nit. argenti. Found in the epidermis, in nails, feathers, &c. (*Bostock, in Nicholson's Journ. XI.* 251.)

VII. OSMAZOME is, probably, only an altered state of fibrine. Soluble in water and alcohol—does not gelatinize. Precipitated by nit. argenti, nit. hydrarg. and acet. and nit. of lead.

VIII. PICROMEL—found principally in bile; resembles inspissated bile in its appearance; soluble in water and in alcohol:

5 atoms	Carbon,	3.75	54.53
1	Hydrogen,	1.25	1.82
3	Oxygen,	3.000	43.65

(*Dr. Thompson, An. Ph.* 14. 69.)

IX. SUGAR OF MILK, according to Berzelius, consists of oxygen, 53.359; carbon, 39.474; hydrogen, 7.167 (*Annals of Philos.* 5.266.)

Dr. Thomson gives the table of the atomic analysis as follows:

4 atoms	Oxygen,	4	48.4
5	Carbon,	3.75	45.4
4	Hydrogen,	0.50	6.2
		8.25	100.0

X. OILS are fixed.—*Fat*—*Cholesterine.*—The former is composed of oxygen, hydrogen, and carbon. The latter, according to Saussure, consists of 84.068 of carbon; 12.672 of hydrogen; and 3.914 of oxygen; and differs little from the other fixed animal oils, excepting that it contains more carbon and less oxygen than they.

XI. ACIDS.—The acids found constituting and ready formed in animal bodies are the following:

1. Phosphoric,
2. Sulphuric,
3. Muriatic,
4. Carbonic,
5. Benzoic,
6. Uric,
*7. Rosacic,
8. Amniotic,
9. Oxalic,
10. Formic,
11. Acetic,
12. Malic,
13. Lactic,
14, Silica.

It may be remarked that the whole of the soft parts of animals consist chiefly of albumen, fibrine, and oils; and the hard parts of phosphate of lime. The other animal principles are only in small quantities, and in particular textures. The oils seldom enter into the structure of the organs of animals, they serve rather to lubricate the different parts, and to fill up interstices.

* Forms the lateritious sediment in fevers, &c.

III. *Individual Textures and Fluids of the Human Body (formed of two or more of the foregoing Constituents.*

The Constituents of the BONES *and* TEETH *of some of the Mammalia, according to the Analysis of* BERZELIUS *and other Chemists.*

Substances analyzed.	Cartilage, with the water of crystallization of the earthy salts and gelatine.	Soda, with a little of the muriate of soda.	Carbonate of lime.	Phosphate of lime.	Fluate of calcium.	Phosphate of magnesia.
Human bones recently dried, - - -	33.3	1.2	11.3	51.4	2.0	1.16
Bullock's bones recently dried, - - -	33.3	2.45	3.85	55.45	2.9	2.05
Osseous parts of human teeth, - - -	28.0	1.4	5.3	61.95	2.1	1.25
Osseous parts of bullock's teeth, -	31.0	2.4	1.38	57.46	5.69	2.07
The enamel of human teeth, - - -	2.0	—	8.0	85.3	3.2	1.5
The enamel of bullock's teeth, - - -	3.56	1.4	7.1	81.0	4.2	3.0

The compact and cellular substance of human bones are, according to Berzelius, of the same composition.

Substances submitted to analysis.	Cartilage.	Phosphate of magnesia.	Sulphate of lime.	Phosphate of lime.	Carbonate of lime.	Water and loss.	
Recent bullock's bones, - -	51.0	1.3	——	37.7	10.0	—	Vauquelin and Fourcroy
A child's first teeth, - - -	20.0	—	—	62.0	6.0	12	Pepys.
Teeth of an adult, - - - -	20.0	—	—	64.0	6.0	10	
The roots of the teeth, - -	28.0	—	—	58.0	4.0	10	
The enamel of teeth, - - -	—	—	—	78.0	6.0	16	
The spine softened by disease.	79.75	0.82	1.7	13.6	1.13	—	Bostock.

Fourcroy and Vauquelin could not discover the fluate of calcium either in the enamel of the teeth or in recent ivory.

Boiling water extracts slowly the cartilage of bone in the form of gelatine. Cold hydrochloric acid dissolves the salts which have lime for their base, leaving nearly altogether untouched the whole of the cartilage. Ammonia precipitates the phosphate of lime from its solution in warm hydrochloric acid: the phospate of lime, however, thus obtained, is accompanied with a considerable proportion of gelatine. Bones submitted to dry distillation, give gelatine, and, as a residue, the carbon of bones, which is a compound of animal charcoal and the salts, with potash for their base; exposed to the air, the charcoal of bones passes into the state of ashes.

Tophus, found in the articulations of the arm, consists of animal matter, with traces of adipocire, 56·2; carbonate, phosphate, and hydrochlorate of potash, 3.2; carbonate of lime, with traces of the carbonate of magnesia, 12.5; phosphate of lime, 28.1. Another specimen contained animal matter, with unctuous and fatty matter, and a little soda, 73.0; carbonate of lime, 10; phosphate of lime, 17. (*John Ecrits Chim.* v. 104.)

The concretions found in persons subject to the gout are composed of the urate of ammonia. (*Wollaston.*)

The marrow of bones. The medulla of the cylindrical bones of the bullock contain membranes and vessels, 1; fat, 96; a reddish serum, 3.

The medulla of the lower part of the radius, and of the tibia, contains a very liquid fat, and neither coloured vessels nor membranes.

The diploe of the extremities of the long bones contain fatty matter and a reddish serum, in very variable proportions.

The vertebræ of the dorsal column contain a deep brown serum, partly concrete, soluble in water, and rarely a trace of fat. (*Berzelius. Nour. Journ. de Gehl.* ii. 287.)

The cartilages dissolve in water kept for a considerable time at boiling point, and form a jelly.

The SYNOVIA *of the human subject* consists of, a yellowish fat, albumen, which constitutes its chief ingredient, an uncoagulable animal matter, soda, chlorate of potassium and of sodium; and the ashes furnish carbonate and phosphate of lime. (*Lassaigne and Boissel, Journ. de Pharm.* viii. 306.)

The synovia of the articulations of the knees of a man was found to consist of a flocculent substance, which coagulated at the temperature of boiling water, and was precipitated by the chlorate of mercury. (*Bostock.*)

Gout appears to change, in some degree, the secretion in the joints affected. Dr. Wollaston, Dr. Pearson, and Mr. Tennant, found the chalk stones formed in this disease composed of urate of soda. Fourcroy has confirmed this analysis; he therefore conjectures that synovia contains uric acid. (*Four.* ix. 224.)

Synovia of a horse.—A. From an articulation which was in a healthy state: soluble albumen, 6·4; animal matter, which did not become concrete, with the carbonate and the hydrochlorate of soda, 0.6; phosphate of lime, 0.15; traces of an ammonial salt, and of phosphate of soda; water 9.28.—*B.* From a joint anchylosed in consequence of a wound: insoluble, fibrous albumen; soluble albumen; free phosphoric acid; the same salts as mentioned above. (*John Ecrits Chim.* vi. 146.)

Synovia of an elephant: reddish, flamentous, of a slightly saline and insipid taste; when warmed or heated by mineral acids it coagulated. It contained a soluble albumen of animal matter precipitated by tannin, and which did not become concrete, in a small quantity; soda and hydrochlorate of potash. (*Vauquelin, Ann. de Chim. et de Phys.* vi. 399.)

The periosteum approaches the chemical properties of cartilage, and yields a small proportion of gelatine.

The ligaments resist for a very long time the action of boiling water, but dissolve at last, in part, like gelatine.

The membranes, as the serous (the pia-mater, arachnoid, pericardium, pleura, peritoneum, &c.) and the skin, dissolve in boiling water, and pass to the state of gelatine.

INTEGUMENT, *Cutis vera*—formed of fibres interwoven like a felt. It yields little gelatine, on maceration in cold water: by long boiling in water it becomes gelatinous, and dissolves completely, and by evaporation it becomes glue. Hence it appears to be a peculiar modification of gelatin. By tannin, and the extractive of oak bark combining with it, leather is formed.

Rete mucosum—"is a mucous membrane, situated between the *cutis vera* and the *epidermis.* The black colour of negroes is said to depend upon a black pigment situated in this substance; but it seems to us to be situated in the inner or flocculent surface of the epidermis. Chlorine deprives it of its black colour, and renders it yellow. A negro, by keeping his foot for some in water, impregnated with that gas, deprived it of its colour, and rendered it nearly white; but in a few days the black colour returned again with its former intensity. (*Fourcroy*, ix. p. 259.) This experiment was first made by Dr. Beddoes on the fingers of a negro." (*Beddoes on Factitious Airs*, p. 45.)

The epidermis possesses the same properties as horn. The internal surface of the epidermis seems to be the seat of the black colour of the negro, and not the rete mucosum. The human epidermis consists of -fatty matter, 0.5; animal matters soluble in water, 5.0; concrete albumen, 93 to 95; lactic acid, lactate, phosphate, and hydrochlorate of potash, sulphate, and phosphate of lime, an ammoniacal salt, and traces of iron, 1. (*John Ecrits Chim.* vi. 92.) The nails of the fingers and toes present an analogous constitution.

HUMAN HAIR may be regarded as fine tubes of a substance similar in all its properties to horn, covered by a white adipocire, (probably furnished by the sebaceous glands of the scalp) and filled with an oily matter, which is either of a greenish black colour, red, yellow, or nearly colourless, according as the hair is black, red, yellow, or white. The ashes of human hair is composed of the hydrochlorate of soda; of the carbonate, sulphate, and phosphate of lime, (and the phosphate of magnesia in that which is white) a considerable portion of silica, oxide of iron in a very marked proportion in black hair, but scarcely to be recognised in that which is white; and a very small quantity of the oxide of manganese.

The sulphur, which is undoubtedly combined in the organization of the corneous or horny substance, is found more abundantly in the red and light coloured hair, than in the black.

The MUSCULAR FLESH. The muscular substance is probably composed of very little more than fibrine, traversed by cellular tissue containing fat, by the aponeuroses and tendons, by vessels containing blood, by lymphatics containing lymph, and by nerves. It is, however, very probable that osmazome, lactic acid, the hydrochlorate and phosphate of soda, and the phosphate of lime, particularly belong to muscular flesh, although they are also found in the blood. Cold water extracts of the muscular substance the red colouring matter of the blood, the albumen, the osmazome, and the salts of the blood: boiling water takes up the cellular tissue reduced to gelatine, and the fat which swims on its surface; the residuum consists of fibrine, a little altered by the boiling, and which yields the phosphate of lime by incineration. The muscular substance of beef gives, by incineration, more lime than that of veal. (*Hatchett.*)

According to Berzelius, the muscular texture contains: fibrine, vessels and nerves, 15.8; cellular substance, 1.9; albumen, 2.2; osmazome, with the lactate and hydrochlorate of soda, 1.8; mucous matter, 0.15; phosphate of soda, 0.9; phosphate of lime, containing a portion of albumen, 0.08; water and loss, 77.17.

Bullock's heart. Osmazome, 7.57; albumen and cruor, 2.76; fibrine with vessels, nerves, cellular tissue, fat, and phosphate of lime, 18.19; an ammoniacal salt and a free acid in an indeterminate quantity: lactate of potash, 0.19; phosphate of potash, 0.15; chloruret of potassium, 0.12; water, 77.04. (*Braconnot Ann. de Chim. et de Phys.* xvii. 388.)

An ossification found in the human heart. It contained a cartilaginous matter and phosphate of lime in nearly equal proportions, with a little carbonate of lime. (*John Ecrits Chim.* 5. 159.)

An ossification found in the veins of the human uterus: membranous substance and phosphate of lime, in nearly equal quantities, with a little of the carbonate of lime and traces of the hydrochlorates. (*John, ibid.* v. 126.)

BRAIN and NERVES. The hemispheres of the human brain: a reddish-brown liquid fat, leaving phosphoric acid by combustion, 0.7; a white fat becoming blacker by fusion, and giving rise to much phosphoric acid by combustion, 4.53; phosphorus contained in these fatty substances, 1.5; osmazome, 1.12; albumen, 7.0; phosphate of potash, muriate of soda, phosphate of lime and phosphate of magnesia, 5.15; water, 80.

The human cerebellum gave the same results.

Medulla oblongata and spinal chord have the same constituent principles, but they contain more of the fatty matter, and less albumen, osmazome, and water

The nerves of the human subject contain less of the liquid and crystallizable kinds of fatty matter, but more of the fatty substance which resembles adipocire, and much more albumen than the brain. (*Vauquelin. Ann. de Chim.* lxxxi. 37.)

The grey substance of the brain of a calf: albumen insoluble in water, 10.0; an unctuous incrystallizable fat, osmazome, phosphate of ammonia, phosphate of soda, phosphate of lime, phosphate of magnesia, hydrochlorate of soda, and traces of iron, 15.0 to 10.0; water 75 to 80.

The white substance of the brain of a calf contained more fatty matter than the grey; it presented traces of silica. The cerebellum of the calf gave the same products as the cineritious substance.

The optic thalami, the medulla oblongata, spinal marrow, and the nerves of the calf, gave results similar to those furnished by the white substance of the brain, excepting that they contained more albumen and less water.

The brain of a bullock contained also phosphate of ammonia, a more solid albumen, a reddish coloured fat, and a crystallizable fat. The composition of the brain of the stag was similar. (*John Ecrits Chim.* iv. 249. v. 162.)

The lymph found in the ventricles of the human brain: gelatine (osmazome?) 0.9; mucus (salivary matter?) 0.3; albumen, 0.6; hydrochlorate of soda and a little of the phosphate of soda, 1.5; water, 96.5; loss, 0.2. (*Haldat, Ann. de Chimie.* cx. 175.)

A soft concretion found incysted in the cerebral pulp of a subject who was afflicted with mental alienation: white grease, 6; semiconcrete albumen, 17.0; cartilaginous substance, insoluble in potash, 18.0; salts with ammonia, potash, soda, and lime for their base, about 2.0; water, 57. (*John Ecrits Chim.* v. 102.)

The pigmentum nigrum is mixed with mucus.

Mucus. The nasal mucus of the human subject contains:—mucus, 5.33: albumen, and salivary matter with a trace of phosphate of soda, 0.35; osmazome, with lactate of soda, 0.3; soda, 0.09; hydrochlorate of potash and of soda, 0.56; water, 93.37. (*Berzelius, Fourcroy, and Vauquelin.*) The mucus of the trachea, according to Berzelius, is similar in its composition.

Saliva. Has a strong affinity for oxygen, absorbs it readily from the air, and gives it out again to other bodies. The human saliva consists of—salivary matter, 0.29; mucus, 0.14; osmazome with lactate of soda, 0.09; soda, 0.02; hydrochlorate of potash, and hydrochlorate of soda, 0.17; water, 90.29. (*Berzelius, Bostock, Thomson, John.*)

Salivary calculi are formed of a membranous substance, containing phosphate of lime.

The tartar of the teeth. Mucus, 1.25; salivary matter, 1.0; animal matter, soluble in hydrochloric acid, 7.5; phosphate of lime, and phosphate of magnesia, 7.90. (*Berzelius.*)

The lachrymal fluid. Animal matter, soda, hydrochlorate and phosphate of soda, and phosphate of lime, 1.0; water, 99.0. The calculi of the lachrymal gland are formed of the phosphate of lime. (*Vauquelin.*)

The gastric juice. The gastric juice ejected by vomiting after fasting for some time resembled, according to Montegre, in appearance, the saliva; it contained flocculi of mucus, and underwent putrefaction as rapidly as the saliva; but sometimes it was acid, and then it did not undergo putrefaction.

Lymph: the liquor found in the thoracic duct of animals which have not taken nourishment for 24 hours, is as limpid as water, does not affect the vegetable colours, does not coagulate either by heat or by acids; it becomes slightly turbid from alcohol, leaves a very small residuum when submitted to evaporation, and consequently appears to contain but very little matter, and only a small quantity of the hydrochlorate of soda.

The lymph of a horse taken from the thoracic duct toward the inquinal region and mesocolon, was of a greenish yellow, translucid, and concreted in 12 minutes into a clear gelatine: the coagulum, which hardly amounted to $\frac{1}{100}$, was similar to fibrine, the fluid contained about 0.04 of albumen, muriate of soda, with a little soda and phosphate of soda. (*Reuss and Emmert, Journ. de Scherer*, v. 681.)

Chyle. The chyle taken from the thoracic duct of a dog, three hours after a vegetable diet, resembled clear milk, deposited a reddish-white coagulum; this coagulum, which had the appearance of fibrine, was to the serum at first in the proportion of 18 to 100; but after being left longer to itself, it increased considerably. The specific weight of the serum was 1.018; it did not coagulate at the temperature of boiling water, but became turbid: after some weeks it became a little sour, without undergoing putrefaction: in 100 parts it contained from 1.8 to 7.3 of solid matter, which consisted of 0.9 of soluble albumen and salts; it contained neither gelatine, nor phosphate of lime, nor any ammoniacal salt.

The chyle of a dog, collected three hours after having eaten meat, had the appearance of cream: its coagulum, a little red, was to the serum at first as 46.5 to 100, but this quantity diminished gradually; the serum became much more turbid by heat

and by the addition of acids than that produced from vegetable food; it underwent putrefaction in three days; it deposited, when allowed to stand, a white and greasy cream, furnished from 7 to 9.5 per cent. of solid matter, consisting of soluble albumen, without any gelatine. Brande observed a substance analogous to the sugar of milk in the serum. (*Marcet, Vauquelin, Brande, &c.*)

Chyle, "when drawn from the thoracic duct, about five hours after the animal has taken food, is an opaque liquid of a white colour; without smell, and having a slightly acid taste, accompanied by a perceptible sweetness. The presence of a free alkali is indicated. About ten minutes after it is drawn from the animal it coagulates into a stiff jelly, which in the course of twenty-four hours gradually separates into two parts, producing a firm contracted coagulum, surrounded by a colourless fluid."

1st. "The coagulum, as appears from the experiments of Vauquelin, (*Ann. de Chim.* 81; 113,) is an intermediate substance between albumen and fibrine. He considers it albumen on its way to assume the nature of fibrine. It is not so stiff, nor of so fibrous a texture as fibrine: it is more easily acted on and dissolved by caustic alkalies. It is insoluble in alcohol and ether, readily dissolved by diluted sulphuric acid, very dilute; nitric acid converts it into adipocire. When burnt it leaves a charcoal, containing common salt, phosphate of lime, and gives traces of iron." (*Thomson.*)

2d. The liquid portion separates albumen on boiling, and contains sugar and a very small portion of a fatty matter, similar to that found in the brain. The same salts as in other animal fluids.

BLOOD. Taste slightly saline, smell peculiar, specific gravity 1.0527. As soon as the vital influence of the vessels ceases to act on the blood, it separates into the coagulum or cruor, and serum. The common proportion is one part of cruor to three of serum. The proportion, however, varies from 1.2 and 1.4. If the separation of fibrine, giving rise to the coagulation, takes place in repose, the fibrine entangles the red particles of the blood; but if the blood be kept in motion, the red particles escape into the serum, and the fibrine is separated into threads.

1st. *Serum.* Possesses the taste and smell of the blood, specific gravity is about 1.0287.

Berzelius found that the serum of human blood was composed as follows:—water, 905.00, albumen, 80.00; muriates of potash and soda, 6.00; lactate of soda, with animal matter, 4.00; soda, phosphate of soda, with animal matter, 4.10; loss, 0.90;—1000.00. (*Annals of Philosophy*, ii. 202.)

"Dr. Marcet found the constituents of serum as follows:—water 900.00; albumen, 86.80; muriates of potash and soda, 6.60; muco-extractive matter, 4.00; sub-carbonate of soda, 1.65; sulphate of potash, 0.35; earthy phosphates, 0.60,—1000. (*Medico. Chirurg. Soc. Transact.* ii. 376.)

"The muco-extractive matter was doubtless impure lactate of soda." "Berzelius is of opinion, that the sulphate of potash, and the earthy phosphates which were found by Dr. Marcet in the ashes of serum, were formed during the incineration. For phosphorus, sulphur, and the basis of lime and magnesia, exist according to him as constituents of albumen."

"Gelatin was considered as a constituent of serum, until Dr. Bostock and Professor Berzelius have shown, that the opinion of its existence in blood is not well founded."

2. *The cruor*, or the clot. Specific gravity about 1.245. Is separated into two portions by ablution in water. 1st, A white solid, elastic substance, which has all the properties of *fibrine*. 2d, The portion held in solution by the water is the colouring matter, with a portion of serum.

"Berzelius and Brande have shown, that this clot is a compound of fibrine, albumen, and colouring matter of blood. According to the analysis of Berzelius, it consists of—colouring matter, 64: fibrine and albumen, 36;—100

"When the colouring matter is incinerated, about one-third of a per cent. of oxide of iron may be extracted from its ashes. This portion of iron is a constituent of the colouring matter, and perhaps the cause of its red colour. (*Thom.* iv. 492.) But in what way it is united to the albuminous portion of the colouring matter remains unknown. When incinerated, the colouring matter leaves $\frac{1}{80}$th of its weight of ashes, consisting, according to the analysis of Berzelius, (which appears to be the most to be depended on,) of the following ingredients:—oxide of iron, 50.0; sub-phos-

phate of iron, 7.5; phosphate of lime with traces of magnesia, 6.0; pure lime, 20.0; carbonic acid and loss, 16.5.—100.0.

Berzelius is of opinion that none of these bodies existed in the colouring matter; but merely their bases, iron, phosphorus, calcium, &c. And that they are formed during the incineration.

"The albumen of blood leaves the same quantity of ashes as the colouring matter. But these ashes contain no traces of iron."

"Dr. Gordon has rendered it probable, that during the coagulation of blood a little heat is evolved." (*Annals of Philosophy*, iv. 139.)

Rouelle has obtained nearly the same ingredients, only in different proportions, from the blood of a great variety of animals.

Fœtal blood. "Fourcroy made some experiments on the blood of the fœtus. He found that it differed from the blood of the adult in three things. 1st, Its colouring matter is darker, and seems to be more abundant. 2d, It contains no fibrine, but probably a greater proportion of gelatin (?) than blood of adults. 3d, It contains no phosphoric acid.—*Four. Ann. de chim.* vii. p. 162.

Diseased blood. 1st. "Deyeux and Parmentier (*Journ. de Phys.* xliv. 451.) ascertained that the buffy coat consists of the fibrine. The cruor, deprived of this substance, is much softer than usual, and almost totally soluble in water.

2. "The blood drawn from several patients labouring under sea scurvy, afforded scarcely any remarkable properties to these chemists, except a peculiar smell, and an albumen which was not so easily coagulated as usual."

3. The blood of patients in putrid fevers gave no sensible alteration in its properties to the examinations of these chemists.

4. "The blood of diabetic patients: the serum of the blood, according to the experiments of Dobson and Rollo, assumes the appearance of whey. Dr. Wollaston has shown, that it contains no perceptible quantity of sugar, even when the urine is loaded with it."

Milk separates into cream, curd, and whey. 1st. Cream is composed of a peculiar oil, curd, and serum. Cream of the specific gravity of 1.0244, was analysed by Berzelius, who found it composed of—butter, 4.5; cheese, 3.5; whey, 92.0—100.0.

2d, Curd may be precipitated by rennet, or the acids, alkalies dissolve it easily. The constituents of curd, according to the analysis of Gay Lussac and Thenard, are as follows:

Carbon - - - - - -	59.781
Oxygen - - - - - -	11.409
Hydrogen - - - - -	7.429
Azote - - - - - -	21.381—100.000.

Dr. Thomson's application of this analysis to the atomic theory.

7 atoms Carbon	5.25	60.87	By doubling the number of atoms, it may be compared with gelatin, albumen and fibrine.	14	atoms Carbon	10.5
1 atom Oxygen	1.00	11.60		5	.... Oxygen	2.0
5 .... Hydro.	0.625	7.24		10	.... Hydrag.	1.25
1 .... Azote	1.75	20.29		2	.... Azote	3.5
	8.625	100.00		28		17.25

Proust has found in cheese an acid, which he calls the caseic acid, to which he ascribes several of the peculiar properties of cheese. (*Journ. de Phys.* lxiv. 107.)

The coagulation of curd probably depends upon the same cause as that of albumen.

3. *Whey* still possesses some curd; on evaporation it deposites crystals of sugar of milk. Towards the end of the evaporation, some crystals of muriate of potash, and of muriate of soda, make their appearance. (*Parmentier Journ. de Phys.* xxxviii. 417.) According to Scheele, it contains also a little phosphate of lime. (*Scheele*, ii. 61.) Fourcroy and Vauquelin, Thenard, Bouillon, la Grange, and Berzelius, have analyzed whey. The latter chemist gives the following as the ingredients of milk deprived of its cream:

Water - - - - - - -	928.75
Curd with a little cream - -	28.00
Sugar of milk - - - - -	35.00
Muriate of potash - - -	1.70

Phosphate of potash - - -	0.25
Lactic acid, acetate of potash, with a trace of lactate of iron	6.00
Earthy phosphates - - - -	0.50
	1000.00

Milk may be made to afford a liquor resembling wine or beer, from which alcohol may be separated by distillation. The Tartars obtained all their spirituous liquors from mare's milk.

It has been ascertained, that milk is incapable of being converted into wine, till it has become sour; after this, nothing is necessary but to place it in the proper temperature: the fermentation begins of its own accord, and continues till the formation of wine be completed. (*Parmentier, Journ. de Phys.* 38. 365.) A great quantity of carbonic acid is extricated during the fermentation of milk. (*Scheele*, ii. 96.) Milk is fermented and kept for many months, or even years, in the Orkney and Shetland Islands; but along with a small portion of alcohol which is formed, the acidity is considerable.

The ingredients of the milk of most animals are nearly the same, the proportion only differs.

The human milk differs from cow's milk. 1st, In containing a much smaller quantity of curd. 2d, Its oil is so intimately combined with its curd, that it does not yield butter. 3d, It contains rather more sugar of milk.

Parmentier and Deyeux ascertained, that the quantity of curd in woman's milk increases in proportion to the time after delivery. (*Journ. de Phys.* 38. 422.)

None of the methods by which cow's milk is coagulated, succeed in producing the coagulation of the human milk. (*Clarke, Irish Trans.* vol. ii. p. 175.)

BILE (human). The following is the analysis of bile, according to Berzelius:—water, 908.4; picromel, 80.0; albumen, 3.0; soda, 4.1; phosphate of lime, 0.1; common salt, 3.4; phosphate of soda, with some lime, 1.0=1000.

Biliary calculi are formed either entirely of cholesterine; or they also contain a yellow concrete mucus, picromel, and rarely phosphate of lime or carbonate of lime. These latter ingredients frequently almost entirely replace the cholesterine. (*Gren. Orfila.*)

CERUMEN OF THE EAR. Vauquelin considers it composed of the following substances. 1st, Albumen. 2d, An inspissated oil. 3d, A colouring matter. 4th, Soda. 5th, Phosphate of lime. (*Fourcroy*, ix. 373.)

TEARS. According to the analysis of Fourcroy and Vauquelin (*Journ. de Phys* vol. xxxix. p. 256,) they are composed of the following ingredients:—1st, Water. 2d, Mucus. 3d, Muriate of soda. 4th, Soda. 5th, Phosphate of lime. 6th, Phosphate of soda.

"The saline parts amount only to about 0.01 of the whole. The mucus contained in the tears has the property of absorbing oxygen gradually from the atmosphere, and of becoming thick and viscid, and of a yellow colour. This property of acquiring new qualities from the absorption of oxygen, explains the changes which take place in tears in some diseases of the eye."

SWEAT contains salivary mucus; osmazome; lactic acid; lactate of soda; and hydrochlorate of potass and soda. (*Berzelius.*)

Thenard found it composed of an animal substance analogous to gelatine; acetic acid; hydrochlorate of soda; phosphate of lime; phosphate of iron, and water.

URINE. The human urine, in a state of health, has a specific gravity of 1.02. It contains urea, 3.01; a matter analogous to saliva, osmazome, lactic acid, lactate of ammonia, and a little urea, 1.714; mucus, 0.032; uric acid, 0.10; phosphate of ammonia, 0.165; sulphate of potassa, 0.371; sulphate of soda, 0.316; hydrochlorate of soda, 0.445; phosphate of soda, 0.294; phosphate of lime, with a little phosphate of magnesia, and a trace of the fluate of calcium, 0.1; silica, 0.003; water, 93.3. (*Berzelius.*)

Besides the constituents of healthy urine, as determined by Berzelius, the following have been occasionally detected in it: albumen; rosacic acid; acetic acid; benzoic acid (in infants); carbonic acid; sulphur; chloruret of potassium; and iron.

Urine which is excreted in the morning, generally contains more of the saline and solid ingredients. Uric acid abounds most in the urine of individuals who live on animal diet. Urine absorbs oxygen from the atmosphere, and passes into a state of putrid fermentation. This is more or less rapid according to the elevation of the temperature; and the quantity of mucus and albumen present in the urine is considerable.

The urine in *diabetes mellitus* has a specific gravity of from 1.026 to 1.05. It generally contains no urea—sometimes a minute quantity of it. It is remarkable for its quantity, and for the saccharine matter which it holds in solution: the saline ingredients are generally present, but in smaller proportions. As the quantity of sugar diminishes, that of albumen increases, and this latter is replaced, as the disease disappears, by urea and uric acid. The chief difference between this urine and that secreted in *diabetes insipidus*, consists in the absence of saccharine matter from the latter.

Icteric urine is frequently yellow and bitter, and contains the principles of bile.

In *acute dropsy* the urine is generally charged with albumen. When dropsy results from disease of the liver, the urine is brown, and deposits a brown sediment.

SEMEN, when ejected, is the product of two different glands, the one fluid and milky, supposed to be secreted by the prostate gland; the other a thick mucilaginous substance, considered to be secreted by the testes, and in which numerous white shining filaments may be discovered: it has a slightly disagreeable odour, an acrid irritating taste, and is of a greater specific gravity than water. As this liquid cools, the mucilaginous part becomes transparent, and acquires a greater consistency; but in about twenty minutes after its emission, the whole becomes perfectly liquid.

This change supervenes without any absorption of moisture from the air, and without its action, taking place equally in close vessels. Semen is insoluble in water before this spontaneous liquefaction, but readily so afterwards. (*Vauquelin, Ann. de Chim.* ix. 70.) When semen is kept in a moist air, at about 77°, it acquires a yellow colour, like the yolk of an egg; it exhales the odour of putrid fish, and its surface is covered by the *byssus septica*. According to Vauquelin, semen is composed of water, 90; mucilage, 6; phosphate of lime, 3; soda, 1. = 100.

The mucus from the uterus of the human subject: gelatine, albumen, phosphate, with an alkaline base in excess. (*John's Chemical Writings*, vi. 158.)

LIQUOR AMNII, which surrounds the fœtus, in the human species is of a slightly milky colour, owing to a curdy matter suspended in it, of a weak pleasant odour, and saltish taste; specific gravity, 1.005; is composed of about water, 98.8; albumen, muriate of soda, soda, phosphate of lime, lime, 1.2 = 100.0. (*Vauquelin and Buniva, Ann. de Chim.* xxxiii. 269–279.) A curd-like matter is deposited on the surface of the fœtus, evidently from the liquor of the amnios. Vauquelin and Buniva have shewn that it is different from any thing contained in this fluid; that it has in its chemical relations a great resemblance to fat. They conjecture that it is formed from the albumen of this liquid, which has undergone some unknown changes. It appears to be of service in preserving the skin of the fœtus from being acted on by the liquor of the amnios, and to facilitate its passage in parturition.

PUS. Its taste is insipid, and it has no smell when cold. Before the microscope it exhibits the appearance of white globules swimming in a transparent fluid, specific gravity from 1.031 to 1.079. When incinerated, the ashes give traces of iron. (*Thomson's Handbook*, ii. 295.) It produces no change on vegetable blues. Alcohol thickens pus, but does not dissolve it; nor does it unite with oils. Soluble in sulphuric acid, but separated on the addition of water. The same is the case with nitric acid. Muriatic acid also dissolves it when heated, and it is again separated by water.

The fixed alkaline leys form with it a whitish ropy fluid, which is decomposed by water, the pus being precipitated. Corrosive sublimate, nitrate of mercury, and nitrate of silver, give a whitish precipitate from its solution, indicating an analogy with albumen.

Expectorated matter yields traces of sulphur, and perhaps also of phosphorus; and it contains the following saline substances:—1st, Muriate of soda, varying from 1½ to 2½ in the 1000 of expectorated matter. 2d, Phosphate of lime, half a part in the 1000. 3d, Ammonia united probably to phosphoric acid. 4th, A phosphate probably of magnesia. 5th, Carbonate of lime. 6th, A sulphate. 7th, Vitrifiable matter, probably silica. 8th, Oxide of iron. The whole of these last *six* substances scarcely amount to one part in the 1000 of expectorated matter.

The proportion of saline matter or albumen present in expectorated matter varies much in different circumstances. The thicker it is, in general the smaller is the quantity of the saline matter: whereas, when very thin, it is often impregnated with salts, especially with the muriate of soda, to a great degree, and tastes distinctly salt and hot.

Liquor of the pericardium. Dr. Bostock (*Nicholson's Journ.* xiv. 147.) considers it to be composed of—water, 92.0; albumen, 5.5; mucus, 2.0; muriate of soda, 0.5=100.0.

Liquor of dropsy. Dr. Bostock found the liquid formed in "*spina bifida*," to be composed as follows:—water, 97.8; muriate of soda, 1.0; albumen, 0.5; mucus, 0.5; gelatin, 0.2; lime, a trace. (*Nichol. Journ.* xiv. 145.)

The same kind of fluid obtained from the head of a child of ten years was examined by Dr. Prout. It faintly reddened litmus paper. Its constituents were as follow:—water, 987.18; albumen, precipitated by nitric acid and heat, 1.66; substances soluble in alcohol (fatty adipocirous matter, lactate of soda,) 1.65; substances soluble in water—9.51, viz. muriates of potash and soda, 6.80; sulphate of soda, and some animal matter not coagulated by heat, 2.71—1000.00. (*Ann. of Phil.* xvi. 151.)

Liquor of blisters. The analysis of Macqueron (*Ann. de Chim.* xiv. 225.) gives it nearly the same constituents as the serum of the blood; from 200 parts he obtained—albumen, 36; muriate of soda, 4; carbonate of soda, 2; phosphate of lime, 2; water, 156—200.

HUMAN FÆCES. Their colour seems to depend upon the bile mixed with the food in the digestive canal: when too light it is supposed to denote a deficiency of bile; when too dark, there is supposed to be a redundancy of that secretion. The following table shews the analysis of BERZELIUS. (*Gehlin's Journ.* vi. 536.)

Water	73.3
Vegetable and animal remains	7.0
Bile	0.9
Albumen	0.9
Peculiar and extractive matter supposed to be formed from picromel.	2.7
Salts*	1.2
Slimy matter, consisting of picromel, peculiar animal matter, and insoluble residue	14.0
	100.0

* The SALTS, their relative proportions.	
Carbonate of soda	35
Muriate of soda	4
Sulphate of soda	2
Amm. phosphate of magnesia,	2
Phosphate of lime.	4

GASES EXISTING IN THE INTESTINAL CANAL. These may be ascribed to three sources:—1st, from the common air swallowed with the food; 2d, from the decomposition of the intestinal contents; and 3d, from the occasional secretion of gas from the mucous surface of the tube.

The gases from the first source are found chiefly in the superior portions of the canal; those from the second source in the lower part, and those from the third, are by no means limited in their situation. It is reasonable to suppose that a large proportion of the azote and carbonic acid is derived from this last source.

From the experiments of Magendie and Chevreul, who examined very soon after death the gaseous contents of the stomach and intestines of four criminals executed at Paris, the following appear to be the proportions and the relative quantities in the different portions of the canal.

1. *Gases in the Stomach.*

Oxygen*	11.00
Carbonic acid	14.00
Hydrogen	3.55
Azote	71.45
	100.00

2. *Gases in the small Intestines.*†

Oxygen	00.00	00.00	00.0
Carbonic acid	24.39	40.00	25.0
Hydrogen	55.53	51.15	8.4
Azote	20.08	8.85	66.6
	100.00	100.00	100.0

* The *oxygen* seems to be absorbed by the blood before it reaches the small intestines.

† Results in the different individuals.

3. *Gases in the large Intestines.*

Carbonic acid	43.50	70.0
Hydrogen and carburetted hydrogen	54.7	11.6
Azote	51.03=100.00	18.4=100.0

4. *Gases in the Cæcum.*

Carbonic acid	12.5
Hydrogen	7.5
Carburetted hydrogen	12.5
Azote	67.5
	100.0

5. *Gases in the Rectum.*

Carbonic acid	42.86
Carburetted hydrogen	11.18
Azote	45.96
	100.00

(*Ann. de Chim. et Phys.* ii. 492.)

THE END.